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# RESEARCH STUDIES

OF THE

# STATE COLLEGE OF WASHINGTON



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# RESEARCH STUDIES of the STATE COLLEGE OF WASHINGTON

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## MECHANISMS OF FREEZING RESISTANCE IN THE NEEDLES OF *PINUS PONDEROSA* AND *PSEUDOTSUGA MUCRONATA*[1]

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### INTRODUCTION

The effect of freezing temperatures on plants is a problem which has long attracted the interest of physiologists. From the viewpoint of applied agriculture, growers are interested in knowing how to distinguish resistant varieties even before planting and how to prepare their growing stock to meet a period of low temperatures without loss. Considerable progress of cultural nature has been made along horticultural and agronomic lines. In general, it is recognized that active shoots are easily susceptible to freezing. For example, in eastern Washington, a region of intense heat and drought during the late summer months and often very severe winters, growers find less difficulty with the winter killing of such plants as the Cuthbert raspberry than do growers in western Washington, where winters are never severe but where the plants have difficulty in ceasing growth activities in the autumn because of mild temperatures and considerable rains. On the other hand, in those regions of eastern Washington where the soil is shallow and where otherwise hardy plants suffer from drought, they are almost as susceptible to winter killing as are plants which have had an excess of water. Thus the climatic nature of the hardening period is nearly as important in determining hardiness as is the plant itself.

[1] Contribution No. 60 from the Botany Department of the State College of Washington.

[2] The data reported in this paper were gathered while the writer was a member of the State College faculty, 1929-37. He is indebted to the National Research Council for a grant which made possible much of the analytical work reported; to the American Association for the Advancement of Science for a grant with which was built a low-temperature refrigerator; to all students past and present who accompanied him on the many trips to Kamiak Butte collecting material; and to the several students who at times assisted with various parts of the work.

[3] Because of the complete absence of low temperatures on Oahu, this line of research can no longer be conveniently followed by the present investigator. Hence the progress made is herein reported with the hope that it can be of use to others who are working with effects of cold temperatures on plants.

The irregularities of climate lead to much early fall and late spring killing of plants which have withstood much more severe temperatures in the middle of winter. The college orchards near Pullman were severely injured during the fall and spring of 1935 and 1936, respectively. A very early freeze caused much damage to the young growth, even though the trees were dormant, and to the bark of the large limbs and trunk, but was limited largely to the north sides of the trunks. It appeared that these parts, less exposed to sunlight, had not dried out sufficiently to be hardened, whereas the bark on the exposed side apparently suffered little if at all. During the early spring of 1936, a period of warm weather during early March induced the initiation of growth activities. The living bark showed all the signs of activity when early in April a freeze occurred during which the temperature dropped to 5°F. and killed the bark on the parts of the trees which, because of their exposure the fall before, had escaped an earlier death.

Numerous incidents of this type have been reported from various sections of the Temperate Zone. Largely because of such idiosyncracies of climate and plant behavior, temperature is regarded by many as the chief determiner of plant distribution so far as native vegetation is concerned.[4] Thus in approaching a study of the mechanism of freezing, it would seem logical to use plants which over a long period of time have adjusted themselves to the erratic variations of temperature and moisture, and which by their very nature have succeeded in establishing themselves in regions where economic plants brought far away from their native habitats are killed time and again. In most instances these economic plants, if compelled to fend for themselves, would soon disappear.

It is, therefore, pertinent to inquire into the growth habits of plants which are native to regions of severe temperature variation and which appear able to withstand severe winters. Probably the simplest way of combating winter temperatures is that used by annual plants. These complete their growth cycle between periods of freezing temperatures and go through the unfavorable period as dormant seeds. That these seeds are extremely resistant is common knowledge, yet the nature of this resistance is not known, although it seems rather definitely associated with a low moisture level and a very low rate of activity. Where the seeds absorb water in the fall, they remain protected by their in-

[4] C. H. Merriam, "Life Zones and Crop Zones of the United States," U.S. Dept. Agr., *Div. Biol. Surv. Bull.* 10 (1898).

activity and by their position on the soil surface or under a mat of fallen leaves, where temperature variations are lessened. In fact, dormancy in these plants is so much a protection against low temperature that many seeds cannot be germinated unless they are first subjected to the low temperature. But once dormancy is broken and water absorption begins, the protoplasm of the seed becomes very susceptible to freezing injury.[5] Other seeds prevent water absorption by means of waxy layers which are broken only after being subjected to frosty soils which in their expansion and contraction finally scarify the seed sufficiently to allow for water intake. But with this habit is always associated a low moisture content and a very low state of vital activity. Seeds have been known to withstand the temperature of liquid air.

However, such annual plants, though they have achieved a high order of efficiency in withstanding unfavorable conditions, must start growth anew each time when seeds germinate. This habit would obviously be disadvantageous in competition. Perennial plants also produce seeds but are capable of carrying their growth gains over into another season. The methods which they have developed to withstand low temperatures are varied. Probably in terms of total numbers, the commonest method is that employed by plants with perennial roots and annual tops. Here the plant produces seed each year but retains its roots and crown, only the exposed parts dying. Whatever may be the evolutionary sequence of these forms, the fact remains that such plants have been successful. Such plants withdraw, so to speak, to the surface of the soil, and, though they are capable of withstanding severe temperatures, nevertheless the severity of the temperature is modified because of the snow blanket which protects them from violent fluctuations. The effectiveness of such blankets is demonstrated during "bare" winters, when killing of perennials is common. The biennial habit can be regarded in the same way.

But where growth conditions are otherwise favorable, the shrub or tree habit seems superior to the root perennials. Here the deciduous plant retains its stems as well as roots. Except for the buds, all its leaves are dropped. Though this seems a wastage, the fact remains that the angiospermous trees compete successfully with the gymnosperm evergreens. Whatever the factors involved here are, it is true that the deciduous plants drop a good deal of their living tissue and need not

[5] T. A. Kiesselbach and J. A. Ratcliff, "Freezing Injury of Seed Corn," *Neb. Agr. Exp. Sta. Bull.* 16 (1920), 1-96.

protect these. The living tissues of the stem are protected and it seems paradoxical that the most active tissues, the cambium and the buds, are in fact the most resistant to low temperatures, provided, of course, that they have had opportunity for proper adjustment. These tissues, however, are probably the most susceptible of stem tissues during activity.

The "evergreen" trees represent those plants most reluctant to drop any of their parts in response to cold. In other words, they retain their leaves, as well as stems, through unfavorable periods. Again, in view of the large areas of the world occupied by these conifers, their success seems to be due in part to frugality with their gains.

It appears probable that all plants employ essentially the same methods of resisting cold. Further, whatever this ability is, it appears to be inherent in all plant protoplasm, inasmuch as seeds or spores of all forms of life are capable of enduring freezing temperatures. At the same time, all actively growing protoplasm is exceedingly susceptible. Yet, following a few weeks of preparation, this same protoplasm is very resistant. It seems quite apparent, then, that the ability to withstand cold requires only an adjustment within the cell.

In order to appreciate the problems involved in the protection of protoplasm, it may be well to review opinions which have been held regarding the nature of killing by freezing. In order to narrow the problem, it is best to eliminate certain types of killing which are caused not by the freezing effects of low temperature, but rather by certain mechanical effects. Thus, in winters when snow is lacking and when day temperatures above freezing alternate with night temperatures below freezing, the biennial or perennial rootstalk type are lifted from their anchorage and killed in this way. It is not uncommon to find the crowns of garden perennials which were resting in a soil concavity when winter started, as much as eight inches above the soil line in spring. This lifting is caused by the movements of the wet soil subjected to alternate expansion and contraction associated with freezing and thawing. Killing of yellow pine seedlings in this way has been observed by Haasis.[6] To be sure, such plants are killed but not because of the effect of cold temperature on protoplasm.

Another cause of killing and one which causes considerable damage is known to orchard growers as sun scald. Here, the bark of trees is

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[6] F. W. Haasis, "Frost Heaving of Western Yellow Pine Seedlings, *Ecology*, IV (1923), 379-90.

killed not by the effect of cold, but by the heating of the sun. Harvey[7] has observed that tree trunks exposed to the winter sun will be heated even on very cold days as much as 18°F. within three minutes when exposed to intermittent sunlight. When the sun disappears, the bark cools rapidly to the temperature of the air, which may be well below freezing. Mix[8] reports temperature variations between the north and south sides of tree trunks to be as much as 25°C. Such alternate heating and cooling may by itself cause killing, but more probably such heating actually desiccates the bark at a time when water cannot move through the tree.

This paper is not concerned with these more or less mechanical effects but rather with the killing of protoplasm as induced by the low temperatures. Among the earliest suggestions as to the nature of this killing are those of Sachs,[9] who pointed out that when freezing actually began the water in the intercellular spaces froze first. Such points of freezing may be somewhat scattered throughout the plant. If similar points of crystallization do not start, water in spaces adjacent moves to these centers of crystallization and builds up considerable masses of ice. I have seen such ice blocks separate bark from wood over a distance of several inches. If, however, crystallization begins at many points within the tissues, this movement of water is not observed, but rather there is a water movement from the interior of the cell toward points of crystallization. Killing under such conditions presumably results from desiccation. In contrast to this concept is the proposal of Iljin,[10] which postulates that killing is often not the result of freezing but rather that of thawing. When the ice crystals thaw, the water is returned to the cell in such haste and disorder that the protoplast is destroyed. It is true that, in many freezing tests, success or failure is determined largely by the method of thawing.

A suggestion of historical interest states that the ice crystals in their formation pierce the cell wall, thereby exposing the protoplast. In the first place, it is extremely doubtful whether crystals would pierce a membrane in their formation, and, in the second place, naked proto-

[7] R. B. Harvey, "Cambial Temperatures of Trees in Winter and Their Relation to Sun Scald," *Ecology,* IV (1923), 261-65.

[8] A. J. Mix, "Sun Scald of Fruit Trees—A Type of Winter Injury," *Cornell Univ. Bull.* 382 (1916).

[9] J. Sachs, "Krystalbildungen bei dem Gefrieren und Veränderung der Zellhäute bei dem Aufthauen saftiger Pflanzentheile," *Ber. d. Verh. Kön. Sachs, Gesell. Wiss. Leipzig,* XII (1860), 1-50. (Quoted from Chandler).

[10] W. S. Iljin, "Über den Kältetod der Pflanzen und seine Ursachen," *Protoplasma,* XX (1934), 105-24.

plasm is not likely to perish if other factors do not play a part. Other suggestions include the idea that pressures against protoplasts which result from the expansion of freezing water suffice to disrupt and kill the cell content. This, however, is hardly likely since protoplasm experiences tremendous pressures under ordinary growth and does not seem to suffer from it.

Several suggestions have been made with reference to the organization of the protoplasm. Gorke[11] suggested the possibility that, while water is being withdrawn from a cell, the dissolved salts which have much to do with the proper dispersion of protoplasm become more and more concentrated until finally the emulsoids are salted out of their vital dispersion, the result being the death of the cell. Whether the freezing process is gradual enough to allow for the accumulation of salts in the immediate vicinity of the proteins remains to be demonstrated, but the suggestion is plausible.

Another possible interpretation involves the suggestion that, as water is withdrawn from a cell and as the temperature drops, the concentration of the inorganic solutes reaches the point where some of the salts crystallize.[12] That the eutectic points of various salts represent a considerable range is commonly known.[13] Because the solution bathing the emulsoid material of a living cell is presumably a physiologically balanced combination of salts, the removal of any ions from such a solution is likely to leave behind unantagonized ions whose toxicity causes a precipitation and killing of the protoplasm.

A point worthy of consideration is that of the possibility of the disconnection of cells from one another. That is, when ice forms between two cells, those cells are forced apart with a resulting breakage of the protoplasmic connections from cell to cell. In this way cells are isolated from the living part of the plant and perish later from a lack of food and other coördinated processes of living tissues. Certainly students are more and more recognizing the importance of the plasmodesmal connections.[14] It is reasonable to suppose that cells which have lost these connections with adjoining cells would suffer. This suggestion

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[11] H. Gorke, "Ueber chemische Vorgänge beim Erfrieren der Pflanzen," *Landwirtsch. Versuchs-Stat.*, LXV (1906), 149-60.

[12] H. Molisch, "Untersuchungen über Erfrieren der Pflanzen" (Jena, 1897), 1-73.

[13] A. W. Grabou, "*Principles of Stratigraphy*" (New York, 1913), pp. 348-50.

[14] S. Mangham, "On the Mechanism of Translocation in Plant Tissues: An Hypothesis with Special Reference to Sugar Conduction in Sieve Tubes," *Annals of Botany*, XXXI (1917), 293-311.

is similar to that which Iljin[15] makes regarding the nature of killing by drought. Maximov[16] points out that those plants which can endure severe wilting are drought resistant. Iljin observed that cells which can withstand severe wilting are those whose protoplasm is not torn away from the points of contact to the walls.

These, then, represent suggestions which have been made regarding the nature of killing by freezing. It is probable that several of these in combination represent the ways in which death actually comes about. It is the purpose of this study to add to our knowledge information regarding the ways in which plants guard against killing by low temperatures.

## MATERIALS AND METHODS

Because this study was being conducted along chemical lines, it seemed desirable to use plants which could afford comparatively large quantities of resistant material and yet materials undiluted with large amounts of dead or otherwise inactive tissues. To use twigs of deciduous trees, necessarily involves larger quantities of xylem as well as dead bark. Thus, though the important living cells of these are confined to the cambium, phloem, and some xylem cells and the relatively unimportant pith, a sample would include varying amounts of relatively inert material. Any variations in composition of the effective tissues would either be masked or induced by the variations in the relative amounts of the ineffective tissues. At the same time it seemed desirable to use some material which lived more than one season, so that developmental processes could be distinguished from those associated with preparation for cold resistance.

The needles of the conifers suggested themselves as suitable materials. Because two conifers, *Pinus ponderosa* and *Pseudotsuga mucronata*,[17] grew reasonably near the college, they were selected for study. They grow on Kamiak Butte, some eleven miles distant from Pullman. This butte reaches an elevation of 3600 feet above sea level and about 1000 feet above the surrounding grass land. On the north face a good stand of timber exists. Collections of material were made on the ridge of the butte, where the yellow pine grows well, and just

[15] W. S. Iljin, "Ueber Absterben der Pflanzengewebe durch Austrocknung und über ihre Bewahrung vor dem Trockentode," *Protoplasma*, XIX (1933), 415-42.

[16] N. A. Maximov, *The Plant in Relation to Water* (London, 1929), pp. 393-96.

[17] Harold St. John, *Flora of Southeastern Washington and of Adjacent Idaho* (Pullman, 1937), pp. 14-15.

off the ridge on the north side, where there is a good stand of vigorous Douglas fir trees.

Temperature records were made for the first series extending from October 27, 1931, through a period of about ninety weeks. The thermograph was placed in a kiosk among the trees from which needle samples were taken. When the needles were collected for the second series extending from March, 1936, to April, 1937, temperature recordings were not made but records were obtained from the semi-official station located at Pullman.[18]

In Series I, weekly collections with one or two exceptions were made over a period nearly two years in length. While new needles were developing, separate collections of the young and old needles were made. Series II started in March, 1936, and continued with monthly collections until April, 1937. In this series, however, current-year, one-year-old, and older needles were separated. Thus materials were collected over a period of three years, two of which were consecutive. All pine and Douglas fir collections were made within not more than fifty yards of one another.

The branches bearing the collected needles were taken to the laboratory, where the needles were stripped from the stems and two-hundred-gram samples were at once autoclaved for fifteen minutes at fifteen pounds pressure. In Series I, only one such sample was taken for each set of needles. In Series II, two such samples were taken. The samples in Series I and one of each of the two samples in Series II were dried in an oven heated to 65°C. until dry. Moisture determinations were calculated from these samples, after which they were ground to sixty-mesh fineness and stored for carbohydrate and total nitrogen determinations made according to methods previously described.[19] In Series II, the second sample was ground at once and used for the determination of the various nitrogen fractions made according to methods already described.[20]

The quantities of ether-soluble materials were determined on the dried samples.

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[18] The writer is indebted to the Soils Department of the State College of Washington for making these records available.

[19] Harry F. Clements, "Hourly Variations in Carbohydrate Content of Leaves and Petioles," *Bot. Gaz.*, LXXXIX (1930), 241-72.

[20] *Ibid.*, "Studies in Drought Resistance of the Soy Bean," *Res. Studies of the State College of Washington*, V (1937), 1-16.

## RESULTS AND DISCUSSIONS

The needles of the two plants differ considerably in their manner of growth and in arrangement of cells. The pine needles developing in fascicles of three grow almost solely in response to a basal meristem. On emergence, the young and still very short needles seem rather completely matured in contrast to the needles of the fir, which occur singly on the stem. The fir needles develop more in response to intercalary growth and hence, when young, are very succulent and sensitive to external conditions. The pine needles remain on the tree for three years, although a few may remain for a part of the fourth year. Often, however, the oldest needles of the two- and three-year-old growths drop, a naked stem being left at the base of each season's growth, a leafy region followed successively by another bare and another leafy portion. The fir needles remain on the plant for much longer periods. Sometimes I have observed needles on wood which was fourteen years old, although generally seven years represents the average extent of retention. Unlike the pine needles, the abscission of needles progresses regularly from oldest to youngest with essentially no abscission among needles of more recent years unless freezing has killed some of the youngest growth. Usually, under these circumstances buds which remained dormant during the previous season become active. In this way some confusion may arise as to the length of time needles are retained.

The structure of the needles is shown in Plate I, Figs. 1 and 2.[21] The cross-section of the pine needle reveals its compact, xeromorphic structure, with its characteristically fluted chlorenchyma. Except for the relatively small amounts of xylem, the leaf is made up almost entirely of living cells all of which may withstand as many as three winters and yet are capable of considerable activity between those periods of dormancy. The cell contents, though not represented in the drawings, are dense, and especially when they are collected in winter considerable difficulty is encountered in de-staining after sections of the needles have been soaked in safranin and later in a counter stain. These winter-collected cells hold Sudan III with greater avidity than do those collected in summer. Sometimes cells are found which are solidly stained with Sudan III. This condition is much less marked in old needles collected in summer, and I have not observed it at all in the cur-

[21] The author is indebted for camera lucida and projection drawings of these needles to two students: Leonard Machlis for the pine drawing and Frank Lavagetto for the Douglas fir drawing.

Plate I. Projection drawings of cross sectional views of *Pseudotsuga mucronata* (Fig. 1) and *Pinus ponderosa* (Fig. 2.).

rent-season needles. Further, the cells of the needles collected especially in May, June, and July are often gorged with starch.

The fir needles are less xeromorphic than the pine, even though they appear to be more resistant to cold. The chlorenchymatous cells have thinner walls than the pine, and there is a tendency for a looser arrangement of the cells. Staining reactions appear about the same as in pine.

After a pine needle is cut it soon exudes a resinous liquid which quickly hardens, whereas the fir needles do not exude any oils on being

cut. When drying, the fir needles yield the turpentine odor so commonly associated with "pine pillows." These materials, however, appear to be limited within the needles to the ducts shown in cross-section.

Under field conditions it appears that in general the Douglas fir is more resistant than pine. On the other hand, the yellow pine is more tolerant of drought. Hence, on mountains one finds the pine growing at lower elevations or on sites more openly exposed. Foresters from whom information has been sought with reference to the relative hardiness of the two plants invariably report greater winter injury to pines than to firs. This has been verified in the brief span of time through which this study was conducted, though the youngest needles of both species have suffered. In later winter following severe temperatures, it is not uncommon to observe a heavy dropping of the oldest fascicles. In other words, it appears that during late fall and early winter the current-year needles of the pine are the most susceptible. If this young growth lives until later winter, it is hardier than the oldest needles, which are nearly three years old. This dropping of the old needles begins in the oldest portion and proceeds acropetally. It is not uncommon, however, to find needles which contain necrotic spots or whose tips have been killed, but these needles remain attached to the stem. On the particular site studied, it was seldom that whole trees were killed. It was more common to find whole branches killed.

The Douglas fir growing within a short distance of these pines never showed severe injury. During one early freeze, the current needles were rather generally killed. In some, this extended also to the one-year-old needles. But during these studies I did not observe any needles two years old and older which were killed. Killing was entirely limited to the current needles and to a lesser extent to the year-old needles. In short, killing of parts on the fir is much less general than on the pine. Further, it is not uncommon to find a pine and fir growing side by side and, after a severe winter, to observe much injury on the pine and none at all on the fir. To be sure, usually the fir is "hiding" behind the pine, but when the temperature approaches –20°F. it is unlikely that the pine provides much warmth, nor when the winds, common to the Palouse country, drive across the mountains in furious gale could the pine afford much protection. It seems that early in its life the fir enjoys the protection of the pine from the sun, but later is quite capable of maintaining itself if moisture is plentiful.

Thus, least resistance to cold is associated with young needles during the fall or early winter. As winter advances the young pine needles are as resistant as the oldest needles but neither is as resistant as the second-year needles. The fir needles increase in resistance as they age, at least through the first three years. Beyond that, there was no opportunity to observe the relative resistance in the field.

It was possible during a short period in 1937 to determine the temperatures which pine and Douglas fir needles could withstand. A refrigerator was constructed with which it was possible to obtain temperatures of –55°F. It was my hope to be able to complete at least a single one-year cycle of killing-point determinations, but only a small part of this study could be completed before I left eastern Washington. The refrigerator was so constructed that pine and Douglas fir boughs could be put into the freezing chamber and still have the stem bases in water on the outside of the chamber. Could the study have been continued, the refrigerator would have been mounted on wheels and taken to the trees. The branches could have been inserted without removing them from the trees. In this way, least injury to the frozen parts would obtain. However, in the short time available for these studies, several collections of materials were made and tested. The boughs were brought into a cool room, subjected to freezing for various lengths of time and to various degrees, removed and covered with wet burlap for several days, during which observations were made. A collection of Douglas fir was made March 30, 1937. This had been exposed to day temperatures of from 50-55°F. and night temperatures between 30-34° F. Needles which were chilled to 32°F., 23°F., 10°F., showed no injury whatsoever. One branch which was left to be frozen to –26°F. was completely frozen. The needles snapped easily. All parts of the branch were killed. It is apparent that the critical temperature was somewhere between 10° and –26°F. In another study on April 3, branches were removed from the refrigerator at 3°, 0°, –3°, –6°, –9°, –12° and –16°F. Branches removed at plus 3° and 0°F. showed no injury. The branches chilled to –3°F. showed much injury to the youngest needles and wood of the large stem. All of the remaining branches were killed throughout except for the buds, which appeared to be perfectly normal.

Another study on April 4 showed 0°F. again to be the approximate critical point. On April 5, the critical temperature seemed to be 11°F. Another series frozen on April 5 shows many of the lateral buds swelling, but the terminal buds were still completely dormant. These lateral

buds were all killed on the branch which was cooled to 20°F. Most of the needles were killed.

On May 21, collections of pine and fir were made. Douglas fir boughs subjected to cooling for 12 hours were removed at 32°, 30°, 28°, 26°, 24° and then at seven three-degree intervals down to 0°F. The boughs removed at 32° and 30° were apparently uninjured. On the branches removed at 28°F. and 26°F., the current needles were killed; on the branches cooled to 24°F., all the year-old needles as well were killed. Some of the older needles showed injury. All the other branches were completely killed.

The current-season pine needles removed at 30°F. showed injury. The older needles escaped killing down to 26°F., but below that point all were killed.

On July 20, 1937, the last collection was made. Fir and pine boughs were removed from the refrigerator at 31°, 29°, 25°, 21°, and 13°F., respectively. All the needles were killed except those cooled to 31°F.

It is, therefore, apparent that the early collections were still fairly resistant; but this resistance as the spring weather advanced was being lost rapidly until these conifers were nearly as susceptible to killing as are ordinary plants entirely incapable of resistance. The approximate killing temperatures at the various dates are given in Table I.

TABLE I

*Killing Temperatures*

| *Material* | *Time of Collection* | *Temp. of General Killing* |
|---|---|---|
| Douglas Fir | March 30, 1937 | Between 10° and –26°F. |
| Douglas Fir | April 3, 1937 | –3°F. |
| Douglas Fir | April 4, 1937 | 0°F. |
| Douglas Fir | April 5, 1937 | 11°F. |
| (showing swollen buds) | April 5, 1937 | 20°F. |
| Douglas Fir | May 21, 1937 | 24°F. |
| Yellow Pine | May 21, 1937 | 26°F. |
| Douglas Fir | July 20, 1937 | 29°F. |
| Yellow Pine | July 20, 1937 | 29°F. |

TEMPERATURE RECORDS

The maximum and minimum temperature records for Series I are reported on Plate II, Fig. 1. The highest maxima and lowest minima

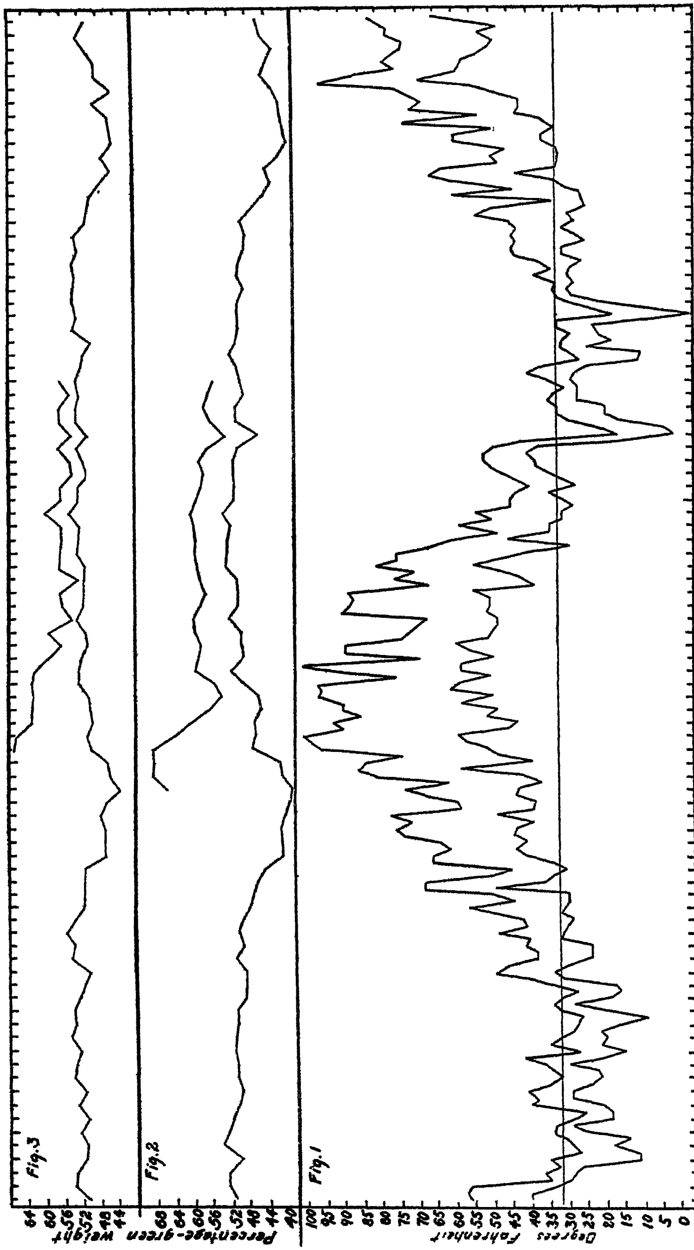


Plate II. Fig. 1: Maximum and minimum (bi-weekly) temperatures recorded for Series I, extending from Oct. 27, 1931, until July 15, 1933. Fig. 2: Moisture content of Douglas fir needles of Series I. Fig. 3: Moisture content of pine needles of Series I. (Long line represents needles one-year-old and older. Short line represents current-season needles.)

for each three-day period are reported for the period between October 27, 1931, and June 19, 1933. The extreme nature of the temperature to which these trees were subjected is shown by the long period of freezing temperatures during the winter and by the intense heat during the summer.

Freezing temperatures began November 11, 1931, and continued until February 24, 1932, with the exception of two warmer periods, one in December and one in January. A low temperature of 12°F. was noted late in November, and one of 8°F. in February. Late freezing occurred in early March with frosts extending well through April. In other words, there were six continuous months of freezing temperatures. During this time, there were six periods in which even the maximum temperatures were below freezing. The most serious of these occurred early in February, when the maximum temperature over a three-day period was 20°F. or twelve degrees below freezing. Following these six months of winter, there is a six-weeks period of spring in which the minimum temperatures vary slightly between 40° and 50° F. and the maximum temperatures vary between 60°F. and 75°F. Beginning with the end of June and extending through August the intense summer heat ranges between 85°F. and 100°F. The minimum temperatures, however, are maintained between 50°F. and 70°F. In September, the maximum temperatures drop about ten degrees and in October frosts are common. Cold weather again begins its six months' cycle in November. On November 27, and for a period of nine days with the minimum temperature reading 4°F., the maximum temperatures were approximately 15°F. below freezing. Such severe and early freezes cause considerable damage, especially to the young needles. The second winter was more severe than the first, with thirty-four consecutive days during which the highest temperatures were at freezing or below. Freezing temperatures continued until toward the end of April. Six weeks of spring again obtained, followed in the middle of June with a maximum of 96°F.

It is, therefore, apparent that the temperatures which these plants endure are extreme. Further, rainfall, which averages somewhat less than 20 inches annually, comes largely during the late fall, winter, and spring. The summer months are periods of intense heat and little moisture.

It should be noted that though the winter temperatures are low, there is very little spread between the maximum and minimum tempera-

tures. During the intense heat of the summer, however, it is not uncommon to find the differences between the maximum and minimum temperatures as great as fifty degrees. This narrow spread in winter and the wide spread in summer appear to be definitely beneficial to vegetation.

On Plate III, Fig. 1, are recorded the temperatures for Series II, extending from March, 1936 to April, 1937. These data were obtained from the semi-official station operated by the Soils Department at the State College in Pullman, about eleven miles from Kamiak Butte. These temperatures would vary somewhat from those which obtain on the butte. The maximum temperatures among the trees would be somewhat lower and the minimum temperatures would be somewhat higher. A severe freeze occurred in early April, 1936, which was very destructive to orchards and to some extent injured the young fir needles and the old pine needles. Each point on the graph is a three- or four-day record for highest and lowest temperatures. Again in early November a severe freeze occurred which caused considerable damage to young needles. Temperatures during this winter were lower, reaching −21°F. late in January. The needles, however, apparently were well adjusted, for the killing was not particularly noticeable except in a few exposures, where whole trees or branches were killed. But favorably situated trees of both species showed little or no damage. The spring months, March and April, were much more favorable to the plants than the previous year. There were light frosts, but no severe freezing occurred.

The rainfall record for the thirteen months during which Series II was conducted is given in Table II and graphed on Plate III, Fig. 2.

TABLE II

*Rainfall in inches*

| | |
|---|---|
| 1936 | |
| March | 1.85″ |
| April | .43 |
| May | 1.17 |
| June | 1.10 |
| July | .08 |
| August | trace |
| September | 1.36 |
| October | .40 |
| November | .10 |
| December | 2.04 |

1937

| | |
|---|---|
| January (Snow and rain) | 3.52" |
| February (Snow and rain) | 2.99 |
| March | 2.02 |
| April | 3.13 |

From these weather records, it is apparent that the winters are long and severe and that, after the plants have withstood this adversity, they enjoy a period of two months during which they grow rapidly before they are exposed to the intense heat and drought of summer. During September and October, there is again a period during which they may build quantities of food, although there apparently is no growth of needles. Then follows another six-month period of winter.

## MOISTURE CONTENT OF NEEDLES

Ordinarily there is associated with the development of resistance in plants a reduction in the moisture content of tissues. This does not seem to be at all true for these conifer needles. A study of Plate II, Figs. 2 and 3, reveals the nature of the fluctuations in Series I. Young developing needles begin their growth with a high moisture content which steadily decreases until well into the winter. The diverse natures of the methods of growth of the two needles are reflected in the moisture contents. The young fir needles approach the moisture levels of the older fir needles much more slowly than do the pine needles. The decreasing moisture levels of the young needles as they approach winter are quite orthodox, but an examination of the moisture levels of the old needles shows the surprising increase of moisture during the winter months, followed by a very marked reduction in the spring months, when growth is very active. Thus, early in December, 1931, the moisture content of the old fir needles reaches 54%. The moisture content varies around 50% for the remainder of the winter. Then in April, while moisture is more abundant than at any other time of the year and the temperature is favorable for the initiation of growth activities, the moisture content decreases until it reaches the lowest point of the season, 38.5%. This occurs before the young needles are emerging and cannot be explained by assuming that the young growth uses water from the older portions. That this is true is further demonstrated by the fact that those branches which are entirely lacking in new needle growth respond in an identical fashion. Therefore, unless this with-

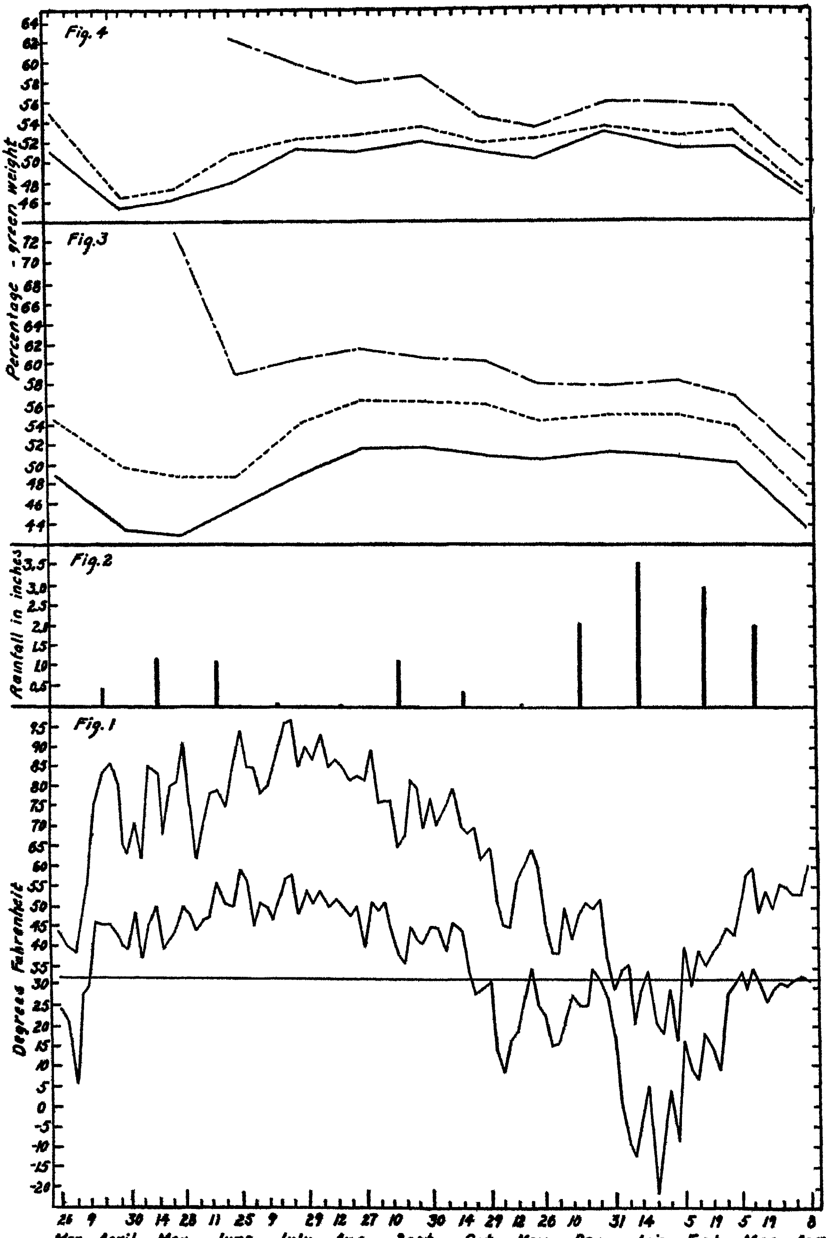


Plate III. Fig. 1: Maximum and minimum temperatures (bi-weekly) recorded for Series II, extending from March 26, 1936, to April 8, 1937. Fig. 2: Rainfall record for Series II. Fig. 3: Moisture content for Douglas fir needles (Series II). Fig. 4: Moisture content of pine needles (Series II). (Continuous lines [Figures 3 and 4] needles two years old and older; short-dash line one-year-old needles; long-dash-short-dash line, current-season needles.

drawal is other than local in its extent, another explanation must be sought. Further, associated with this decrease of moisture is a very rapid decrease in the resistance of the plant to low temperature (Table I).

As growth slows down in June and July—when rainfall is low, temperatures are extreme, and humidity is very low (sometimes less than 10%)—the moisture content of the needles increases to within a few points of the season's high! A similar perversity of these organs was repeated each spring during which these studies were made. Though the pine needles are generally higher in their moisture levels than the fir needles, the same anomalous variations in moisture appeared.

On Plate III, Figs. 3 and 4, is shown the moisture content of the needles of different ages for the years 1936-37. Since in this series the needles were more completely segregated as to their ages, the series makes possible a more discriminating study. To be sure, because these curves are constructed from data gathered at monthly intervals, they tend toward greater smoothness than those shown for Series I. The same reduction in moisture in spring is noted in the year-old and older needles as was shown above. It is apparent that moisture content of needles of all ages used follows identical trends. Even more strikingly is this shown in Series I, the data for which were gathered at weekly intervals. This is true despite the fact that the needles of different ages have distinct moisture levels. In Series II the current needles have the highest moisture levels; the year-old needles are intermediate, and the oldest needles have the lowest moisture content. There is, however, a smaller difference between the year-old and the oldest pine needles than there is between corresponding fir needles.

When the moisture levels of the needles of various ages are compared with their apparent resistance to freezing, the inverse relationship is readily seen. The young needles can withstand least cold and have the highest moisture level; the year-old needles are intermediate with respect to both moisture and resistance; and the oldest needles have the lowest moisture content and, with one exception of old pine needles late in their last winter, are the most resistant. In Series I, the moisture levels of the pine needles are higher than those of the corresponding ages of fir needles.

In this comparison, the relationships are strictly orthodox, but, so far as each group of needles is concerned, the highest moisture level is recorded during the coldest periods and the lowest levels are associated

with greatest growth activities. It appears, then, that though low moisture content is associated with resistance, it is not an important element in the mechanism of resistance where the efficiency of the real mechanism is such that it can provide for this anomaly.

Much attention has been directed toward the nature of the water held by cold-resisting tissues. Efforts to correlate so-called "bound" water with resistance have failed. Meyer[22] reports the same amount of bound water in pine needles in summer and winter, and yet the resistance of needles in summer is non-existent, whereas in winter it is great. It must be admitted, however, that methods so far employed have by their very nature precluded the possibility of correlations. Nearly all of the bound water determinations have been made on watery expressions of plant tissues. It appears that only the water not bound to solid materials is thus obtained. In many studies reported, only a few drops of water can be obtained for measurement, yet this mere fact is of greater importance than the amount of bound water within the expressed sample. In other words, it seems as though the "free" water only is expressed and all the tightly bound water is left behind. Though I am aware of the difficulties of determining the bound water of the residue, mere impracticability is of no importance in excluding the idea and certainly cannot be regarded as final. On the other hand, if the bound-water determinations which have been made do, in fact, represent the true picture of the distribution of water in the cell, it is obvious that there is little correlation between it and resistance. It becomes much more important to determine the mechanism which prevents the free water from freezing, for in these studies there was little indication that the needles were frozen, because they remain easily pliable even during sub-zero temperatures. If the free water does not freeze, is it not, in fact, bound? Certainly when one grinds these old needles, or needles gathered in winter, there isn't much indication of free water. Even after two grindings, samples containing 55% moisture come out of a plate-grinder mill in dry, lumpy bits of materials.

The sudden reduction in the moisture content of all the needles as they come out of winter and enter into growth activity is probably indicative of deeply seated changes with reference to the manner in which the water is held within the cell. It must be remembered that

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[22] B. S. Meyer, "Seasonal Variations in the Physical and Chemical Properties of Pitch Pine Leaves, with Especial Reference to Cold Resistance," *American Journal of Botany*, XV (1928), 449-72.

this reduction in the moisture content comes at a time when the humidity is relatively high and when there is more water available in the soil than at any other time. The temperature at this time is mild. Associated with this sudden decrease is a marked decrease in the ability of the plant to resist freezing, yet ordinarily the reverse association is asserted. It seems very apparent that the amount of water which a plant organ contains is much less important as a factor in resistance than the way in which that water is held. When the needles are in a primordial state, their moisture content is high, yet not much higher than that of needles in the middle of winter. Still, the most resistant needles have lower moisture levels than those with less resistance. In spring the moisture level drops to the lowest point, but associated with this very marked drop is an equally marked decrease in the resistance of the plant to freezing! Probably all this means that the water in young developing needles is held in a manner comparable to that in which the old needles carry on their spring activities, whereas the winter water is held in a very different manner by a mechanism which is capable of protecting larger amounts of water than found in spring, but which is nevertheless more effective if the water content is reduced.

It is well, then, to turn our attention to the mechanism itself. Water is that which must be prevented from freezing, or the deleterious effects of its freezing are controlled. There is good evidence that the protoplasm itself when nearly free of water is not killed by temperatures as low as –75°C. It is only that protoplasm which is dispersed in water and which is active that is susceptible to destruction by freezing. Accordingly, protoplasm so organized that energy changes (and hence metabolic activity) are reduced to a minimum is resistant to killing by low temperatures.

Probably the best index of the least common denominator of living substance is the protein content. Though there is danger that such an indicator includes storage material, and also that there is more to the complex which makes up life, nevertheless, it is reasonable to suppose that this material at least includes a larger portion of the material which is carried through successive generations than that included in any other fraction.

On Plate IV, Figs. 1 and 2, the total nitrogen expressed as protein nitrogen and based on the residual dry weight[23] is reported for Series

[23] The residual dry weight is obtained by subtracting from one gram of dry material all the materials within the gram for which values were obtained by analysis.

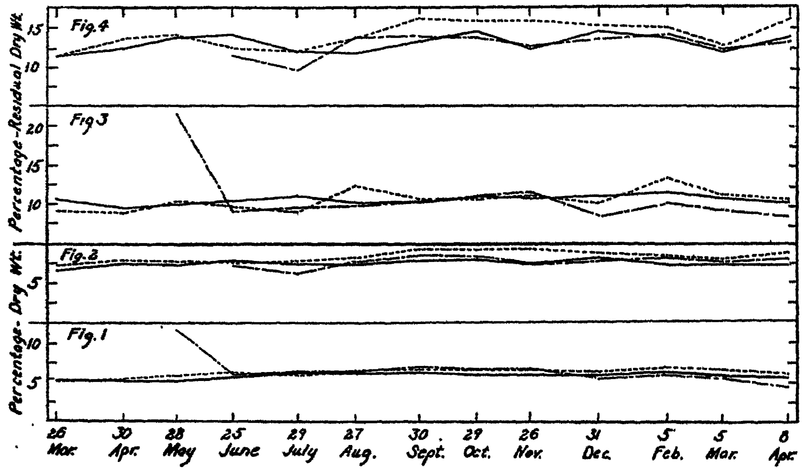


Plate IV. Fig. 1: Total nitrogen (protein) of Douglas fir needles (percentage dry weight). Fig. 2: Total nitrogen (protein) of yellow pine needles (percentage dry weight). Fig. 3: Total nitrogen (protein) of Douglas fir needles (percentage residual dry weight). Fig. 4: Total nitrogen (protein) of yellow pine needles (percentage residual dry weight). (Continuous lines represent two-year-old and older needles. Short-dash lines represent one-year-old needles. Long-dash-short-dash lines represent current-season needles.)

II.[24] Essentially, these observations are in order: (1) The protein content of the three ages of fir needles when expressed on the residual dry weight basis remains essentially constant. To be sure, in the very young needles the N/Residual-dry-weight ratio is very high, but this is caused by the fact that the amount of residual dry weight is very low. Once the needles are mature, there seems to be little or no quantitative change. About the same relationships obtain within the pine needles, although the protein nitrogen tends to be more abundant in the one-year-old needles. The very young pine needles, unlike the fir, do not have a large proportion of nitrogen. This is explainable when the manner of growth of the two needles is recalled. (2) The second observation is that the amount of nitrogen expressed on the residual dry weight is uniformly lower in fir needles than in pine. This means that in fir needles there is relatively more cell wall and less cell content than in

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[24] Though chemical data were obtained for the weekly periods over the ninety weeks covered in Series I, only the data gathered in Series II will be used in the discussion. The results obtained in the latter are nearly identical with those of the longer study and were derived from samples more completely segregated on the basis of age.

pine. It appears that there is an advantage to the fir needle in that if there is less of the least common denominator to protect, other things being equal, it should be easier to prevent its killing. (3) The third observation worthy of note is that the nitrogen content of these evergreen needles, particularly fir needles, is low as compared with that of deciduous leaves. This is particularly apparent when the total nitrogen expressed as protein is reported on a simple dry-weight basis (Plate IV, Figs. 3 and 4). The protein nitrogen of the fir needles fluctuates between 5 and 6.5%, and that of the pine needles is between 6.5 and 9.5%.

That there is a comparatively low nitrogen metabolism in these needles is indicated by the relatively small quantities of soluble organic nitrogen fractions. Of the various fractions of soluble nitrogen compounds, nitrates, ammonium nitrogen, and amide are present only in traces. Alpha amino acids together with the diamino acids and basic nitrogen recovered by means of precipitations with phosphotungstic acid make up nearly the whole soluble nitrogen fraction. These fractions (Plate V, Figs. 1-4) represent comparatively small proportions of the total nitrogen. Diamino nitrogen expressed as lysine rarely exceeds 0.5% of the residual dry weight and shows no tendency to fluctuate in response to temperature changes. The alpha amino acids are

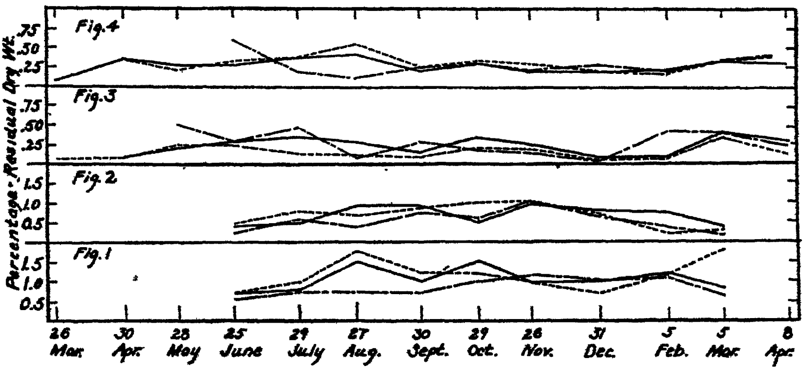


Plate V. Fig. 1: Alpha-amino nitrogen (glycine) content of Douglas fir needles. Fig. 2: Alpha-amino nitrogen (glycine) content of yellow pine needles. Fig. 3: Di-amino and basis nitrogen (lysine) content of Douglas fir needles. Fig. 4: Di-amino and basic nitrogen (lysine) content of yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

generally maintained at a higher level representing an average of about one per cent of the residual dry weight. This fraction shows a distinct tendency to be abundant during August when drought is severe, a relationship already noted in angiospermous plants.[25]

Thus when the protein nitrogen is expressed on a dry-weight or residual-dry-weight basis, there appears to be no marked difference between needles of different ages, even though there is a marked difference in their respective resistance to cold. However, since the cell wall

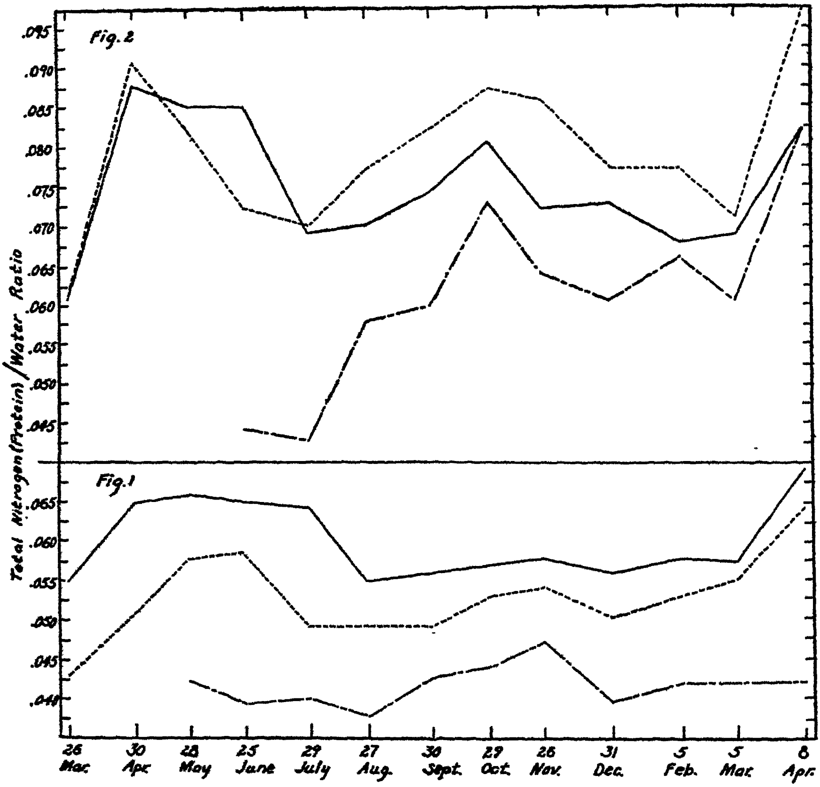


Plate VI. Fig. 1: Protein-water ratio for Douglas fir needles. Fig. 2: Protein-water ratio for yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

[25] Harry F. Clements, "Studies in the Drought Resistance of the Sunflower and the Potato," *Research Studies of the State College of Washington,* V (1937), 81-98.

itself is probably of little consequence in resistance, it may be better to report this important cell component on a basis which is directly related to material instrumental in killing; namely, water. On Plate VI, Figs. 1 and 2, the ratio of nitrogen to the water in the tissue is reported. The curves are strikingly related to the relative resistance of the several plant materials. Among the fir needles, the oldest needles have the highest ratio, the one-year-old needles are intermediate, and the young needles are lowest, in the exact order of resistance. The ratios of the pine needles are equally striking. The young pine needles are of the same ratio during the early spring months, but during the second winter the year-old needles are at a higher level than the oldest needles. This correlates perfectly with observations regarding the relative resistance of these needles of several ages. In other words, within a given plant, the needles having a higher protein/water ratio have a greater resistance to killing by low temperatures. That this relationship is one of association, rather than one of strict causation, is indicated by several conflicting relationships. The pine, which under field conditions is less resistant to freezing than the fir, has considerably higher ratios. Further, the highest ratios within each series are obtained when the resistance is known to be at the lowest levels. What all these conflicts probably mean is that the lower the moisture content in relation to the amount of protein content the greater is the ease of protection, and associated with age is a considerable improvement in the mechanism for the prevention of killing. Thus the nitrogen content (percentage of dry weight) of the various ages of fir needles is about the same. Since the moisture content is highest in the young needles and lowest in the oldest, the protein/water ratio is highest in the oldest needles. In other words, for a given unit of the material which must be protected against killing, the smaller the amount of the killing agent, water, the easier it is for the mechanism used in the protection of the protoplast to accomplish its purpose.

When compared with the fir needles, the pine needles have a higher protein-water ratio. But in these, there is relatively a larger proportion of protein to dry material, and also a greater (though proportionally smaller) amount of water per unit of dry material. Thus the pine has relatively a greater amount of essential material to protect against the killing action of larger actual amounts of the killing agent with a comparatively smaller amount of dry matter in which must be found the mechanism used in protection. In other words, in studying winter

resistance, it is necessary to know (1) the relative amounts of vital materials to be protected; (2) the amount of the material responsible for killing, water; (3) the amount of the mechanism available which prevents the killing agent from acting on the vital material; and finally (4) the nature of the vital material as related to its capacity to maintain its organization at a very low energy level. It would seem necessary to consider also the temperature. Yet a moment's thought will reveal the fact that all four adjustments are affected by the stimulus of low temperature. It seems definitely true that the ability of a plant to resist cold is actually built up upon exposure to cold. In this way it seems impossible to study resistance in plants during a growing period, for it seems that resistance is an attribute of only those plants which are being exposed to low temperatures. Fortunately, the stimulus of a certain low temperature induces a response within the plants capable of developing resistance which guards them against a lower temperature, which in turn becomes a new stimulus for a second response. This relationship obviously applies only to vegetative tissues, and not to seeds which have reduced their moisture, increased their protective mechanisms, and reduced their rate of metabolic activity in response to stimuli associated with the plant itself and only slightly modified by environmental conditions.

## CARBOHYDRATE METABOLISM

As with the nitrogen metabolism, the extent of the discussion and data presented regarding the carbohydrates, in the interests of economy of space, will be limited to Series II, since the results are much the same in Series I, and since Series II represents a more complete segregation of the needles with respect to age.

The reducing sugars and sucrose (Plate VII, Figs. 1 and 2) are reported together. Since the conversion from one to the other is so easily accomplished by tissues, it is most likely that their functions in resistance are much the same. In regard to the sugar content of fir needles, based on the residual dry weight, two generalizations are in order: first, three general maxima are apparent, two associated with cold weather and one, in August, with drought, although the one maximum in January, 1937, is at the highest point for all the different ages; second, with the exception of three of the thirty-seven points plotted, the older, more resistant, needles have greater sugar contents than do younger needles. The pine needles show much the same reactions to

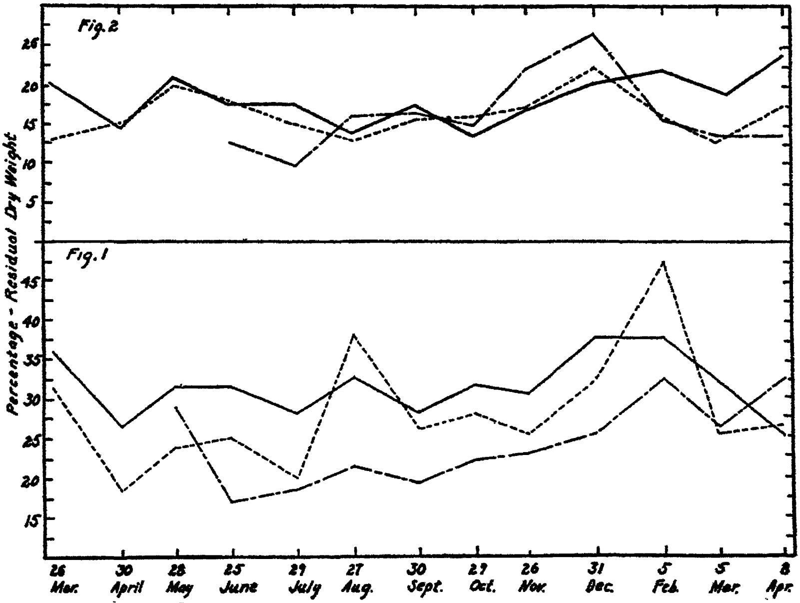


Plate VII. Fig. 1: Simple sugars and sucrose content of Douglas fir needles. Fig. 2: Simple sugars and sucrose content of yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

climate. The highest levels are found during the winter months. A second general maximum is found associated with rapid synthesis in spring. The association with age observed in Douglas fir is lacking in the pine. A further comparison with the fir shows the pine needles to have a much lower sugar level at all times, ranging from 10-25% less. Particularly is this true in winter, when the fir needles contain sugar equal to between 32 and 47.5% of their residual dry weight.

The association of sugars in cold resistance has been shown by other workers.[26] Work with bacteria,[27] cabbage,[28] and protein dispersions[29]

[26] Herman Muller-Thurgau, "Ueber Zuckeranhäufung in Pflanzentheilen in Folge niederer Temperatur," *Landw. Jahrb.*, XI (1892), 751-828.

[27] A. F. Vass, "The Influence of Low Temperature on Soil Bacteria," *Cornell Univ. Agr. Expt. Sta. Memoir*, XXVII (1919), 1039-74.

[28] N. A. Maximov, "Experimentelle und kritische Untersuchungen über das Gefrieren und Erfrieren der Pflanzen," *Jahrb. Wiss. Bot.*, LIII (1914), 327-420.

[29] R. B. Harvey, "Hardening Process in Plants and Developments from Frost Injury," *Journal Agricultural Research*, XV (1918), 83-112.

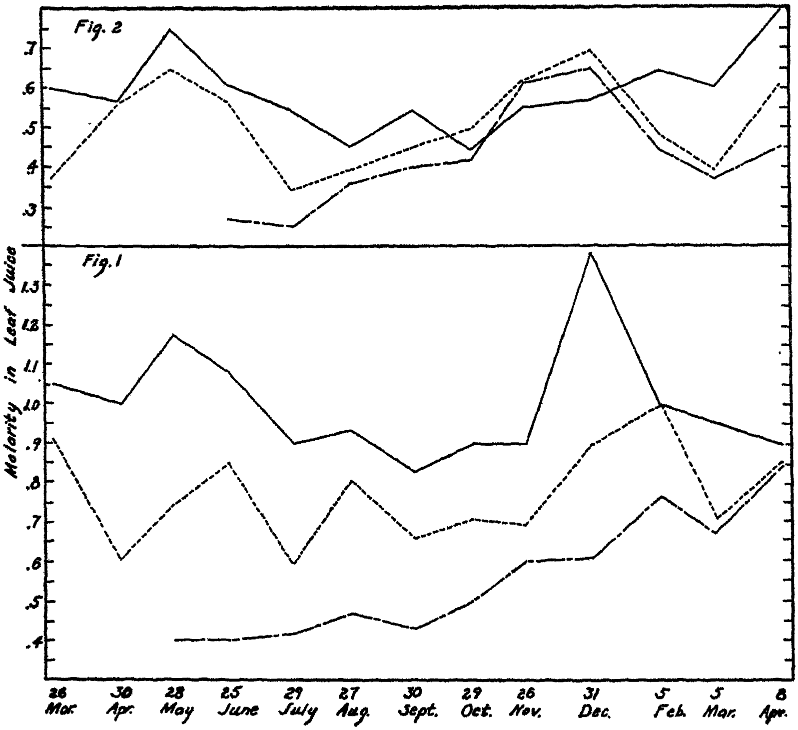


Plate VIII. Fig. 1: Simple sugars and sucrose content of Douglas fir needles expressed in molarity of protoplasmic solution. Fig. 2: Simple sugars and sucrose content of yellow pine needles expressed in molarity of protoplasmic solution. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

shows that the greater the sugar concentration the lower are the temperatures to which cells can be cooled without injury and the smaller the precipitation of dispersed proteins. Apparently, the effect of the sugar is disproportionate to its influence on the freezing point. It is reasonable to assume, however, that its effect is based on its concentration in water. On Plate VIII, Figs. 1 and 2, the actual molar concentrations of the sugars found in the needles are reported. When so expressed, they arrange themselves without exception on the basis of age; the oldest needles of the fir have the highest sugar molarity. This corresponds exactly to their relative resistance to freezing. The same general associations can be made for pine needles. Quite obviously, the

high sugar levels in May and June are the result of rapid synthesis which decreases rapidly with summer drought. On the other hand, the tremendous increase of these sugars in winter must be the result of some other process.

Though some observers[30] have suspected that assimilation occurs during the winter in conifer needles, it seems only remotely possible that the great accumulation of sugar here can be so explained. Such a synthesis would have occurred during a period when for the most part even the maximum temperatures were below freezing. Since several stages in photosynthesis are chemical, it must be recognized that at sub-freezing temperatures the rate would be exceedingly low. Enzymes are known to be active at temperatures near the freezing point, but, again, this explanation cannot apply here, since there was no change in the known polymers of the simple sugars.

The third possibility of explanation is that the proteins during greater activity hold large quantities of sugar as integral parts within themselves, thus holding them out of the reach of the analyst, but releasing them in response to the stimulus of low temperature. I am inclined to the last hypothesis. Is it not possible that proteins with sugars as an integral part are associated with rapid vegetative activity which, because of its vital instability, is very sensitive to unfavorable conditions, and that the expulsion of the carbohydrate moiety from the protein complex renders them stable (though still organized on the living pattern) and hence insensitive to the low temperatures? These data seem to suggest such a relationship.

### STARCH

The quantity of starch in the needles is reported on Plate IX, Figs. 1 and 2, and though the curves fluctuate greatly during the periods of rapid synthesis, they level out consistently during the fall and winter months—an indication that there is little synthetic activity during this period. The irregular curves during May, June, July, August, and September should not cause surprise, for microscopic examination will at times show cells literally gorged with starch and quite empty at others. Though the starch content is probably of no importance in

[30] Kuchi Miyoke, "On the Starch of Evergreen Leaves and Its Relation to Photosynthesis during the Winter," *Botanical Gazette*, XXXIII (1902), 321-40; L. A. Ivanov and I. M. Orlova, "Zur Frage über die Winter-Assimilation von Kohlensäure unserer Nädelhälzure," *Zhurn. Russk. Bot. Obshch.*, XVI (1931), 139-57.

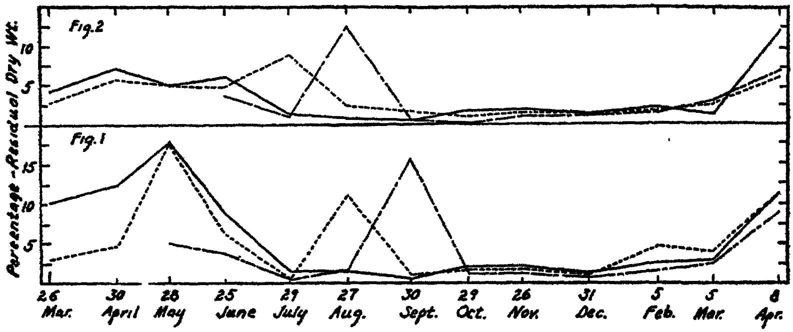


Plate IX. Fig. 1: Starch content of Douglas fir needles. Fig. 2: Starch content of yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.

freezing resistance, at least its absence during November, December, January, and February indicates little, if any, synthetic activity. It is during this period that the needles achieve their greatest efficiency in resisting low temperatures.

### ACID-HYDROLYZABLE CARBOHYDRATES

The acid-hydrolyzable carbohydrates are reported in two portions: A (Plate X, Figs. 1 and 2) and B (Plate X, Figs. 3 and 4). The "A" portion when graphed shows something of the same trends as does starch with the very marked difference in the amounts contained during the periods of reduced synthetic activity. In view of the known heterogeneity of this group of reserves, it is quite likely that the large increases in spring and early summer associated with rapid synthesis involve different portions of the reserve from that found uniformly through the drought and freezing periods. The relationships here are the same as have been noted in previous papers.[31] Thus these materials in mature, dormant needles are equal to approximately 10% of the residual dry weight, but during periods of rapid synthesis there is a variable amount over and above these more permanent portions. The pine needles seem consistently to have somewhat greater amounts of these materials than fir needles. This probably is associated with their greater resistance to drought. The "B" fraction, because of its con-

[31] Harry F. Clements, "Studies in the Drought Resistance of the Soy Bean," *Res. Studies of the State College of Washington,* V (1937), 1-16.

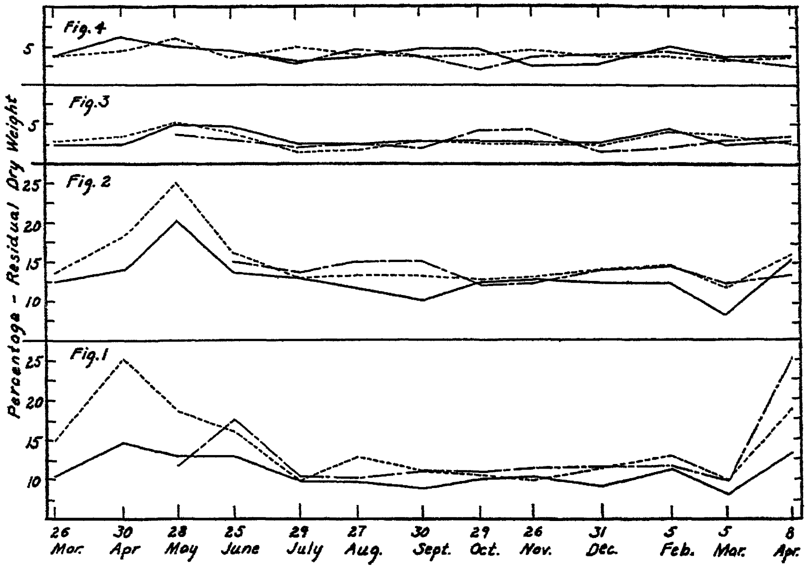


Plate X. Fig. 1: Acid-hydrolyzable carbohydrates (A) for Douglas fir needles. Fig. 2: Acid-hydrolyzable carbohydrates (A) for yellow pine needles. Fig. 3: Acid-hydrolyzable carbohydrates (B) for Douglas fir needles. Fig. 4: Acid-hydrolyzable carbohydrates (B) for yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

stancy, seems merely to represent more of the permanent carbohydrates of the "A" portion which were released on longer hydrolysis.

Unfortunately, the shortage of time prevented a detailed study of this permanent portion of the acid-hydrolyzable carbohydrates. It would be very desirable to know more about the chemical and physical nature of this fraction. In Table III are reported the amounts of uronic acids obtained from four selected samples based on age and time of collection.

TABLE III[32]

*Uronic Acids*

| *Sample* | *Time of Collection* | *% Residual Dry Weight* |
|---|---|---|
| Old Douglas Fir | May | 11.01 |
| Needles | January | 11.06 |
| Current-Season | May | 10.55 |
| Douglas Fir Needles | January | 11.10 |

[32] The writer is indebted to Mr. H. Mottern of the U.S.D.A. for the uronic acid determinations.

It is apparent from these figures that the uronic acids are very abundant in these needles and that once the complex is formed of which the uronic acids are a part, there is no further change. This strengthens the viewpoint that within the hydrolyzable portion there is a portion which is stable in quantity and another which takes part in the daily march of synthesis. Uronic acids, associated with materials of hydrophylic nature, are no more abundant when synthesis is active than they are in winter, when there probably is very little, if any, synthesis. Further, such a fraction represents a considerable portion of the dry matter. Uronic acids which were removed from the complex by hydrolysis equalled roughly eleven per cent of the residual dry weight; reducing sugars which are in part associated with these materials obtained from a similar hydrolysis equalled approximately fifteen per cent of the residual dry weight. Other materials not obtained in these two fractions would increase this quantity considerably.

That these materials could be valuable in drought as well as cold is easily seen when it is remembered that they are quite capable of gel formation. But these materials are as abundant in summer as in winter. Of what value then can they be? Several facts are pertinent here. In the first place, it is conceivable that, so far as these materials are concerned, they may well exist in a different state during a drought or period of low temperature from what they do during periods of rapid synthesis. There are several observations which support such an hypothesis: (1) The cytological reactions of the cells during winter and drought periods are certainly different. In semi-dormant cells, the cell content is easily preserved by fixatives and, when stained, absorbs the dyes readily and holds them with considerable force, whereas active cells fix less easily and de-stain more rapidly. This phenomenon has been observed by others.[33] (2) When fresh sections are examined during active growth and synthesis, the cell wall appears more definitely as a margin about the protoplast than in the needle of the same age in winter, when the cell wall appears indistinctly merged with the cell content much as though it had swelled inward. (3) As was described above, the loss of the property or mechanism of resistance comes about suddenly and starting with this loss there is a marked reduction in the

[33] S. Dunn, "Relation of Hydrophylic Colloids to Hardiness in Cabbage, Brussel Sprouts, and Alfalfa Plants as Shown by the Dye Absorption Test," *Plant Physiology*, VIII (1933), 275-86.

moisture content of all the needles even before any new growth begins. This decrease in the moisture content is most unorthodox unless it is associated with very marked changes within the cell content. It must be remembered that this loss occurs at a time when there is a plentiful supply of external water, when the days are mild. Further, this reduction of water occurs at a time when the plants are carrying on rapid synthesis. Then, later in summer, when drought occurs, when the humidity is very low and the temperature very high, the moisture content of the tissues increases to winter levels. Surely, such anomalies must be associated with considerable protoplasmic adjustment.

ETHER EXTRACT

Ether-soluble materials (Plate XI, Figs. 1 and 2) have long been known to be associated with winter resistance in plants.[34] In all vege-

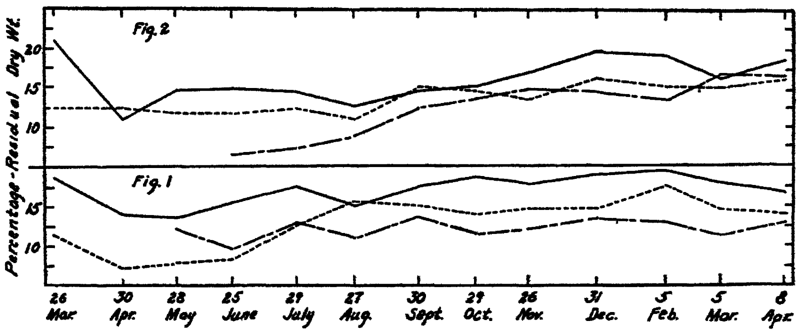


Plate XI. Fig. 1: Ether-extract of Douglas fir needles. Fig. 2: Ether-extract of yellow pine needles. (Continuous lines represent two-year-old and older needles; short-dash lines represent one-year-old needles; long-dash-short-dash lines represent current-season needles.)

tative portions there seems to be an accumulation of fatty materials, and the pine and fir needles seem to be no exception. An examination of the graphs from the various ages of fir needles shows again a rather uniform correlation between the amounts of these materials and age of needle. Further, there is a marked reduction in the quantity of these

[34] K. Peretolchin, "Die Aenderung von Reservestoffen bei unseren Bäumen in der Winterruheperiode," *Mitteil. des Forst.-Inst. St. Petersburg,* XI (1904), 3-42 (from an abstract in *Ber. d. Deutsch. Bot. Gesell.,* XLII [1924], 420-29); A. Meyer, "Die angebliche Fettspeicherung immergrüner Laubblätter," *Ber. d. Deutsch. Bot. Gesell.,* XXXVI (1918), 5-10.

materials in late spring. Thus, in Table IV are shown the percentages for one-year-old and two-year-old needles in May and December.

TABLE IV

*Ether Extract*

| | | | |
|---|---|---|---|
| *1-year-old fir needles* | | *1-year-old pine needles* | |
| May | 8.02 | May | 12.2 |
| December | 14.40 | December | 16.4 |
| *2-year-old fir needles* | | *2-year-old pine needles* | |
| May | 13.50 | May | 14.5 |
| December | 19.20 | December | 19.6 |

There is, therefore, a marked increase in the abundance of this extract as winter approaches. To be sure, in this crude extract are materials other than glyceryl esters of the fatty acids. Others, however, have shown that this is the material of importance. The pine needles show the same relationship, although there is a smaller spread between the two extremes. It is of interest here also to observe that if the fats are associated with winter resistance, and there is little cause for doubt, they are built by the plant in anticipation of winter.

The problem now to be considered is the role which fats may play in protecting the living cell against freezing to death. It is hardly probable that they serve the same functions as they do in animals: namely, to provide an immense store of heat and to act as a layer of insulating material. To be sure, the plant ultimately uses the fats in respiration, but there is no suggestion that this occurs except after the winter is over. Further, because plant temperatures are close to air temperatures, there is little need for insulating material. In other words, the problem here is of an uncertain type. Do the fats and oils in tissues other than storage tissues merely result from the inactivity of protoplasm or are they of value in carrying the organism through periods of adversity? Evidence may be obtained supporting either contention. On the one hand, vegetable organs high in fats are not necessarily tolerant of unfavorable conditions. Thus, young developing seeds are still very susceptible to cold temperatures, even though their fat content is high. On the other hand, these seeds with the same amount of fat but with increased dormancy and a reduced water supply are extremely resistant. Yet dormancy by itself is not of uncompromising

importance, for it is well known that many perfectly dormant bulbs, tubers, etc., are very susceptible to freezing.

In other words, dormancy which is not associated with reduced water is no more capable of protecting an organ than is a low moisture level without dormancy, as these conifer needles show. It is only when the two are associated that protection results, and with this association, fats are invariably associated. Some evidence suggests a correlation between melting points and the latitudes in which the fats were produced. Further, oils in emulsions are known to aid undercooling.[35] There is, however, a further possible relation. The mere presence of the fat in a system of high viscosity during periods of very low temperatures would certainly help to prevent or at least resist the removal of water from a cell, a process associated with freezing injury.

## GENERAL DISCUSSION AND CONCLUSIONS

Whatever else may be involved, winter resistance implies the ability of a plant to prevent completely the crystallization of water within its cells or to enable it to resist deleterious effects of such crystallization where it does occur. Careful distinction must be made between the resistance of plants to comparatively light frosts and the ability of plants to withstand very low freezing temperatures. Hardened cells of annual plants have been known to withstand comparatively severe frosts, yet such cells would not withstand severe and prolonged winter temperatures. In such plants, this capacity to resist frost is rather directly associated with drought resistance. In other words, frost resistance and drought resistance seem to result from the same mechanism. In general, a plant which has been successfully hardened to a drought, so that it is not actually suffering from a lack of water, is more frost resistant than a member of the same species which has not been so hardened. Yet it is perfectly apparent that intensive freezing resistance and drought resistance are not synonymous. Thus, though conifers are in general the very acme of indifference to low temperatures, they are irregular in their response to drought. The Douglas fir is more resistant to low temperatures and less resistant to drought than the pine. Further, perennial plants of the xeromorphic type are exceedingly resistant to drought and yet may not be at all resistant to cold. The pineapple grows and produces a juicy "fruit" while it is growing in a soil so near the wilting coefficient that prickly

[35] R. B. Harvey, *Plant Physiological Chemistry* (New York, 1930), pp. 187-90.

pears growing nearby actually wilt. Yet the pineapple is notorious for its susceptibility to frost temperatures. It is possible that only where to low temperatures, they are irregular in their response to drought. resistance is not a corollary of freezing resistance, for xeromorphic lichens and mosses which readily lose 95% of their water to drought without injury are exceptionally resistant to low temperatures.[36]

It is apparent that the killing agent directly or indirectly is water. It is also apparent that protoplasm of all species of plants producing seeds or resistant spores can be resistant to extremely low temperatures when properly adjusted to it.

What is not apparent, however, is this: Is the chemical nature of the least common denominator of vital substance the same during periods of winter resistance as it is during periods of vegetative activity, when it is extremely sensitive to low temperatures? The very sudden increase of soluble carbohydrates in the needles of fir and pine following periods of low temperatures might well indicate some modification of the basic material. Certainly, synthesis could not possibly account for the large increases noted, for it must be remembered that portions of the photosynthetic process are chemical, and the low temperatures would bring the rate of the process not far from zero. Enzymes, on the other hand, have been presumed to act at near freezing temperatures, but where such action occurs, it should be possible to account for the accumulated hydrolysate by observing corresponding decreases in some related polymer. Such is not the situation, however, in the studies here reported. There are no corresponding decreases of any of the known polymers of reducing sugars. Whence, then, come these? It is obvious that they come from some source which escaped analysis through alcoholic and aqueous extraction and acid hydrolysis. Clearly, there is the possibility that this sudden appearance of reducing substances may represent an actual excretion from the protein complex, the nature of the latter being thereby changed to a point where there is little irritability and certainly little or no destruction by cold. This conclusion may account for the extreme susceptibility of some drought-enduring vegetative organs of plants which are not at all resistant to low temperature except in the seed stage.

It appears that, when death occurs, it is directly or indirectly caused by the precipitation and disorganization of the protein complex within

[36] Elizabeth McKay, Photosynthesis in *Grimmia Montana," Plant Physiology,* X (1935), 803-09.

the living cells. Sugars are known to reduce the amount of precipitation in protein emulsoids which have been subjected to low temperatures. In other words, whatever the origin of the sugar which accumulates during periods of low temperature, its presence in considerable quantity is advantageous to living cells in their resistance to cold.

Thus the accumulation of sugar is of significance for possibly two reasons: Its appearance indicates a stabilizing change in the nature of the protein complex and second, its association with the system helps to stabilize the protein suspension. This appears to be one phase of the mechanism of freezing resistance. The proteins appear to be modified and stabilized. It appears that all plants are capable of such changes. Some, however, are capable of rendering this change only in the seed stage, whereas others have the capacity to produce such changes in ordinary vegetative organs.

The second phase of the mechanism which apparently distinguishes hardy from non-hardy plants is that which enables ordinary vegetative cells to prevent crystallization of water. I am convinced that at no time during the three winters in which collections were made, even though temperatures were –20°F., did the needles contain frozen water. At all times the needles were pliable, and bending them did not result in any snapping, as would be expected if the cells were frozen. When needles were collected in summer and frozen artificially, the needles were frozen so that they broke very easily. But never in the field could such a condition be found. Chandler[37] discredits the idea of undercooling by pointing out that crystals of ice on the outside of the plant would act as seed-crystals for the water within the plant. There are several points which might be offered against such an hypothesis: (1) Between these "seed" crystals and the water within the plant is a layer of wax or a layer of suberized tissue interspersed with numerous stomata. It is reasonable to assume that the wax layer would effectively prevent the seeding influence from progressing inward. In all probability the stomata on these needles are closed during the winter. It is possible that such closure prevents crystallization inward. (2) Even though ice is formed in the intercellular spaces, there is no evidence of which I am aware which demonstrates that crystals of ice can set off crystallization within a membrane. Freezing of water within the cell may result in the withdrawal of water from the cell, provided such withdrawal is

[37] William Henry Chandler, *Fruit Growing* (Cambridge, Mass., 1925), pp. 509-66.

possible in the particular tissue. It is highly improbable that this withdrawal obtains within pine and fir needles, and the mechanism of this prevention will be discussed below.

It is cogent to inquire whether there are any demonstrable instances of undercooling in plants in which it is reasonably possible to observe it. The difficulties of using sectioned materials for such observation are self-evident. Lawn grass suggested itself as a good subject for such study. Pullman is subjected to late spring frosts which often are sufficiently severe to blacken the young succulent blades of grass. Frequently, however, frost covers the grass heavily without apparent injury. If this frosted grass is walked across, however, every step shows up a little later as footprints of blackened, killed grass, whereas the undisturbed grass is uninjured. This, then, indicates one of two things: either (1) that the grass was frozen solidly and walking over it caused a crunching of the frozen tissue, thereby killing it, or (2) that the inside of the grass escaped crystallization and, though it was cooled to a temperature at which it could freeze, either a jar or a lower temperature was required actually to set off crystallization. In other words, were crystals of ice present in the leaf? Now, it is reasonable to suppose that, if any of the cells of the delicate organ were frozen, most of them would be. The leaf should be stiff and easily broken. Such, however, is not the case. With care, the frost crystals can be removed with very cautious brushing. The reaction of the leaf to this is of interest. Sometimes this brushing was too vigorous and the leaf turned black later. At other times the operation was performed successfully and the leaf did not blacken. Such a successfully brushed leaf was pliable—not stiff. On the other hand, grass blades with frost on, which were punched with needles, were killed all over. It seems that this represents a case in which undercooling forces are pitted in a delicate balance against crystallizing forces. Now, it is apparent that the common practice of dousing frozen plants with water might well be expected to give varying results. Where the non-resistant plants are already frozen throughout, a cold water bath probably does no good. But where the plants are heavily frosted but undercooled, cold water would quickly thaw the frost and warm the plants above crystallization temperatures, and thus prevent possible crystallization. It is possible that in many such treatments, unwashed plants would recover as completely as those whose frost had been thawed off, provided nothing operated to set off crystallization. On the other hand, unwashed plants might well be sub-

jected to a further cooling before the atmosphere warms naturally and thereby allow for crystallization and killing.

It is unnecessary to point out that undercooling in the case just described is mild compared with the undercooling which would be necessary in winter periods when for weeks the temperatures are below freezing. However, the moisture content is lower in these conifer needles than in succulent grass, and the chemical composition is very different. That the components of the winter cells are very different from young grass leaves hardly need be discussed. On the one hand, though the needles contain some 55-60% moisture, the material is still essentially dry and crumbly when ground. The grass leaves, on the other hand, literally squirt their water when subjected to a similar grinding. Thus, because the water of the conifer cells is held differently, it is entirely possible to expect much greater undercooling in well-hardened plants. As was shown above, the large amount of hydrophylic substances present in the cells of the needles studied, and with good circumstantial evidence that these materials are dispersed through the cell content in the winter and not in summer, it is reasonable to conclude that a gel condition obtains during low temperatures. Further, associated with this gel is a comparatively large quantity of fatty materials. That such a mixture could well cause considerable undercooling is at least suggestive to any one who has attempted to determine freezing point depression with extracts containing large quantities of organic material. To such persons, who have stirred the sample vigorously without successfully preventing undercooling, the argument that slight bending of branches caused by wind movement would prevent undercooling in living plants is not of great weight.

What the mechanism of this undercooling phenomenon in conifer needles might be, is suggested by their chemical composition and the arrangement of their cell content. The large amounts of protoplasmic materials could, as they harden with the lowering temperature, hold the water more and more firmly, preventing thereby the reorientation of the water molecules into the pattern necessary for crystal formation. Bound water by some is defined as the water which will not freeze at –25°C. But this temperature is only –13°F., whereas the lowest temperature observed during these studies was –21°F. Yet crystallization apparently did not occur. According to such logic, there is no such thing as free water in properly adjusted winter cells. In other words, the balance at which water is poised in truly resistant plants is not so

delicately poised as in frost-resistant or succulent plants, but is held firmly and thus prevented from rearrangements into crystals. It thus appears that, only when the cohesive forces in water necessary to reorientation overcome the adhesive forces of the hydrophylic materials, crystallization and freezing to death occur. When such a point is reached will be determined by two things: the amount of water present in the tissue and the amount of the surface or hydrophylic materials which holds it.

Further, evidence is available in Plate II, Figs. 2 and 3, and Plate III, Figs. 3 and 4, with reference to the amount of water present in the needles. The higher amount of water present during the winter is a result of low transpiration and high moisture content in the air. The hydrophylic material within the cell cannot avoid being higher in moisture, but when warmer temperatures come in early spring, when the humidity is still high and when soil moisture is available again, then the moisture level of the needles drops. At this time, also, the resistance of the needles disappears—a fact pointing to the obvious conclusion that the mechanism for resistance has disappeared. The implication is that the hydrophylic and fatty materials have lost their winter influence, and with that has come a rapid loss of water. Then later in the summer, when the air becomes very hot and dry, the response is toward a reconstruction of the hydrophylic system, a partial binding of water or a prevention of water loss. Then as winter temperatures come on, thereby increasing the swelling properties of the hydrophylic materials, the least common denominator undergoes its change and the winter mechanism is complete.

It is apparent from the large number of observations made by horticulturists and agronomists that death from low temperatures results only when crystallization occurs. (To be sure, the time element is important here. If certain plants are kept at low temperatures but above the freezing point for long periods of time, they are killed, but from a cause very different from the direct effect of low temperature on the protoplasts.) However, not always when crystallization takes place does death result. It probably is in place here to discuss the possibility that crystallization of water could occur in the conifer needles at lower temperatures than those observed during these studies. When these needles gathered in spring and summer were frozen in the refrigerator, they froze solidly and death resulted. Unfortunately, it was impossible because of time limitations to conduct such tests on

winter-collected materials. It is, however, probable that in the colder regions crystallization does occur and judging from the widespread success of conifers in high mountains, death does not always follow.

Crystallization results in a concentration of dissolved materials and possible precipitation. The danger to the living cells presumably comes in salting-out effects, also in unantagonized toxicity. Another result of crystallization is the withdrawal of water from the cell content to the outside. Then as warmer temperatures develop, the water rushes back into the cell, whereby are caused local disruptions which destroy the organization of the cell content and result in death. But whatever the real nature of the cause of death may be, it is associated with violence to the organization of the protoplasm. It seems reasonable to observe that, where crystallization occurs and death does not result, the violence of the change has been either subdued completely or at least considerably reduced.

How, then, can the mechanism described above function to reduce this violence? In the first place, any mass of living material containing a mixture of fatty materials and viscous, gel-forming materials would surely be nearly solid at low temperatures. In other words, water in such a system would be either discontinuous or if still continuous would be spread over the swollen solid surfaces in comparatively thin films. Should regions of crystallization develop, water movement toward such points would meet tremendous resistance. Rather, it is likely that crystallization within such a system would occur at numerous points and in very small crystals. Likewise, the dissolved solutes, if precipitated, would be scattered throughout the cell. It is probable that under the circumstances these salts are effectively insulated from the vulnerable parts of the cell content. Thawing in such a protected system would involve no major movements and certainly little violence. A general concentration of salts is avoided. Further, should water be removed from a cell during freezing, the drought mechanism would protect against death and the fatty materials would resist a rapid return of the water when thawing did occur.

In conclusion, it appears that the large quantities of sugars, hydrophylic hemi-celluloses, and fatty materials during winter conditions are definitely favorable to low-temperature resistance. But the mere presence of these materials is not enough to assure protection. The state in which they exist is equally important. A measure of this state might be secured by obtaining a value for metabolic activity. Such a factor

would be inversely proportional to resistance. Also, the quantity of water present as well as the protein content is inversely proportional to resistance.

SUMMARY

1. A study of the variations in chemical composition of pine and fir needles is reported with reference to the mechanism of freezing resistance. Pine and Douglas fir needles were collected in two series: Series I covered a period of ninety weeks beginning October 27, 1931, and ending July 15, 1933. Samples of needles produced currently as well as samples of mature needles were collected each time. Series II represents a study extending from March, 1936, to April, 1937. Collections were made at monthly intervals. Needles of each species were collected on the basis of age: current-season, one-year-old, and two-year-old and older needles.

2. The moisture, total nitrogen, and carbohydrate fractions, and ether extract content of the needles were determined in Series I. The same procedure was followed in Series II with th addition of a more complete study of the nitrogen fractions.

3. Temperature and rainfall records were compiled for correlation purposes.

4. Field observations of killing temperatures were recorded. In 1937, a refrigerator was constructed by means of which killing temperatures of the needles were determined artificially.

5. The moisture content of the needles varies according to season. The highest moisture levels were observed in the middle of winter and the lowest just when the needles were changing from winter to spring conditions. The youngest needles always had the highest moisture content, and the old had the lowest. In general, pine needles had higher levels than the Douglas fir. These results correlate rather well but inversely with resistance to low temperatures.

6. The total nitrogen of the needles when based on the residual dry weight shows no essential variations in relation to either season or age once the needles are completely developed. The insoluble nitrogen material comprises most of the total nitrogen. Nitrates, ammonium compounds, and amides exist only in traces. The alpha-amino and the basic nitrogen fractions make up nearly all of the soluble nitrogen. There seem to be no marked variations of these fractions which could be correlated with winter temperatures.

7. The carbohydrates showed striking variations and correlations with age and season. The soluble sugars, reducing sugars and sucrose, were at maxima during the coldest part of winter. A second accumulation was correlated with rapid synthesis in spring and early summer. The origin of the large amounts of sugar in winter and its significance is discussed fully. The highest concentrations are found in the oldest needles, and the fir needles contain considerably more sugars than the pine needles. The sugars appear to play a major role in resistance to low temperatures.

Starch is very abundant during rapid synthesis but otherwise is present in very small amounts.

The acid-hydrolyzable material is rather definitely shown to be made up of two portions: one which is very abundant during rapid synthesis and the other which when once developed changes very slightly. Uronic acid fraction represents a large part of the residual dry weight. The more permanent acid-hydrolyzable materials seem also to be involved in the resistance mechanism.

8. Fatty materials show a strong correlation with winter temperatures.

9. The roles which these various materials may play are discussed at length with special reference to the mechanism of freezing resistance.

# FIELDING'S *UNIVERSAL GALLANT*

Emmett L. Avery
*Assistant Professor of English*

The fact has not been noted before, I believe, that Henry Fielding seems to have had *The Universal Gallant, or, The Different Husbands* ready (or almost ready) for production over a year before it made its appearance on the stage on February 10, 1735, at Drury Lane Theatre. What happened to delay its appearance is not clear.

Late in 1733 and early in 1734 the fortunes of Drury Lane, then under the control of Highmore, were endangered by the secession of actors from it under the leadership of Theophilus Cibber, who had begun performances in the New Theatre in the Haymarket. On December 8, 1733, when Drury Lane apparently needed support, Fielding seems to have been ready to aid it with a revision of an old play and with a new one. The following item appeared in the *Daily Adverstiser* on that date:

> We hear from the Theatre Royal in Drury-Lane, that the celebrated Performance call'd the Author's Farce, (which was some years ago received with universal Applause) will be reviv'd there immediately after Christmas with very great Additions, and that it will be succeeded by a New Comedy of the same Author's, call'd the Universal Gallant, or the Different Husbands.

Although the *Author's Farce* did not make its appearance quite so soon as it was expected, it did appear on January 15, 1734, at Drury Lane, and had a moderately successful revival. Instead, however, of next bringing forth *The Universal Gallant*, Fielding put *Don Quixote in England* into rehearsal at Drury Lane, which had now passed into the control of Fleetwood. According to W. L. Cross, Fleetwood, pressed by the competition of Rich's pantomime, pushed *Don Quixote in England* aside in favor of a pantomime. Apparently piqued, Fielding transferred his theatrical productions to the New Haymarket, but here again, instead of presenting *The Universal Gallant,* he offered *Don Quixote in England* on April 5, 1734.

Not until February 10, 1735, did *The Universal Gallant,* which certainly had been in the process of writing if not completed by December of 1733, appear. Is it possible that, in spite of all that has been said of Fielding's disappointment at the failure of this comedy, he had recognized its weaknesses and let it lie unproduced in favor of *Don Quixote in England,* and had brought it forth later only when he had no stronger play to offer?

# AN ECOLOGICAL STUDY OF KAMIAK BUTTE[1]

LOWELL A. MULLEN

Kamiak Butte is a quartzite prominence located ten miles north of Pullman, Washington. It is three miles in length and at its highest point 1100 feet above the Palouse hills and 3650 feet above sea level. Because of a great diversity of exposures, this small area offers the principal plant groups found in the entire region.

Methods used were, for the most part, conventional. Instruments for measuring habitat factors were Friez soil-air thermographs, Livingston atmometers, Weston illuminometer, and Youden H-ion concentration apparatus. Photographs were used extensively to record invasions, cover types, and other important features. Miscellaneous records were collected over a period of four years, and continuous detailed records for two years.

Two main types of plant cover are present: prairie and forest. In these two types are represented three life zones: Arid Transition timberless (*Festuca-Agropyron* prairie), Arid Transition timbered (*Pinus ponderosa* consociation with prairie remnants), and Canadian (*Pseudotsuga-Larix* mictium. The latter, which contains some 2.3% Abies grandis, is characteristic of the steep north slope. All stages of succession, from lithosere to climax, are found on the Butte.

Total of species referenced were:

| | |
|---|---|
| Angiosperms: | 160 |
| Gymnosperms: | 4 |
| Pteridophytes: | 4 |
| Bryophytes (Musci): | 39 |

Attention was given to such pertinent items as: (1) extremes and daily and seasonal fluctuation in soil and air temperatures and humidity in type sites, (2) variation in light intensity in relation to time of day, cloudiness and vegetation layers, (3) the general effects of biotic factors in relation to succession, (4) soil pH and organic content in relation to successional series, (5) rainfall data, especially in relation to difference in penetration due to soil and plant cover, (6) seasonal fluc-

[1] Abstract of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Botany, State College of Washington (1933). Published in condensed form in *Northwest Science*, X (1936), Aug., pp. 13-21.

tuations in soil moisture at 4″ and 8″, (7) air movement and evaporation, (8) trends of succession.

The following serves as a general summary of information obtained.

The evidence is that at one time Kamiak was covered by prairie vegetation, and that the essential steps in the succession to the tree climax, on the north slope, are still represented on the ridge and the south slope. The trend on the south slope is toward a tree cover. The climax, however, will be different from that for southerly draws and the protected north slope. A *Pinus ponderosa* savannah seems the probable climax, with a *Pinus-Pseudotsuga* mictium in the draws. The north slope seems well adapted to regeneration of the *Pseudotsuga-Albies* climax. (The area was heavily logged about 1885.)

As the climax is approached, certain environmental factors are modified:

EDAPHIC
(a) increase in organic content
(b) increase in acidity
(c) increase in water-holding capacity and wilting coefficient
(d) more uniform temperatures

CLIMATIC
(a) decrease in air movement
(b) decrease in rate of evaporation
(c) decrease in light values

VEGETATIONAL
(a) tendency toward pronounced layering
(b) production of conifer tree dominants
(c) decrease in number of plant species

The evidence is that whenever the prairie is disturbed, a succession, tending toward a *Pinus ponderosa* climax, is begun. There is no evidence of a return to prairie conditions.

The prairie grasses most persistent following *Pinus* invasion are *Festuca* and *Poa*; and the shrubs, *Symphoricarpos* and *Spiraea*. Seedlings of both *Pseudotsuga* and *Pinus* are light tolerant, but those of *Pinus* are better able to withstand the resultant heat and soil desiccation.

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# RESEARCH STUDIES

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**Pullman, Washington**

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RESEARCH STUDIES of the STATE COLLEGE OF WASHINGTON

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# THE PROBLEM OF PAROLE

## PART II. SENTENCES IN RELATION TO PAROLE AND ITS VIOLATION

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This study of parole and its problems is a study of the male inmates who were paroled from the Washington State Penitentiary during a period of about seven years, ending in December, 1932.

In Part I,[1] the first installment of this study, consideration was given to the more general aspects of the problem of parole. The data presented related to the extent of parole violation for different periods of time between March, 1927, and December, 1932, the extent of violation in different forms of crime, and the frequency of previous penal commitments for different classes of parolees.[2] In Part II, the present installment of the study, consideration will be given to different lengths of sentences received by the inmates in the more frequent crimes, to different lengths of sentences served by them, and to the relation between sentences served and parole violation.

During the period of this study the inmates under consideration had received both minimum and maximum sentences as determined by the courts.[3] The Parole Board, however, was required to give more consideration to the minimum sentence than to the maximum, because each inmate automatically became an applicant for parole at the end of the minimum period and the Board had the problem of deciding whether the inmate at that time was ready for parole. Furthermore, the maximum sentence is commonly longer by many years than the minimum sentence, so that, if the Board saw fit to hold an inmate beyond the minimum, the practical problem became one of determining how much

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[1] Carl I. Erickson, "The Problem of Parole," Part I, *Research Studies of the State College of Washington,* IV (1936), 57-66.

[2] Part I should be referred to for an explanation of the different kinds of parole, automatic and executive, and of such terms as violator and non-violator.

[3] A new state law which went into effect in July, 1935, permits the courts to fix only maximum sentences. This law also made provision for a full time Board of Prison, Terms and Paroles, which has the function of fixing, within certain restrictions, the length of sentence to be served (*Laws of Washington* [1935], Sec. 2, Chap. 114, pp. 309-311).

longer it was necessary or desirable to hold the inmate. The records show that an inmate is rarely required to serve his maximum sentence.

As pointed out in Part I, there are many factors to be considered in determining fitness for parole: age of the inmate, nature of the crime, previous penal record, conduct in the institution, character traits, and many others. It should be noted, however, that the effect of these factors considered in combination is finally judged in terms of time. Thus in one instance, because of the inmate's age, his attitude toward crime, his previous record, his home relationships, etc., it is decided that one year, the minimum sentence, is sufficient to assure acceptable behavior during and following the parole period. In another instance, because the combination of factors is considered as less favorable than in the first instance, a two-year sentence is regarded as necessary although the minimum sentence was the same for both cases. The problem of determining fitness for parole is thus finally decided in terms of the length of time to be served. This fact suggests the need of considering the duration of sentences in relation to parole and its violation.

Because the minimum sentence had to be given some consideration by the Parole Board and was a factor in determining when the parole period should begin, it seems necessary to note how long such sentences are. Accordingly, Table I is presented to show the frequency of minimum sentences received in each of the seven most common forms of crime.[4] The inmates in those seven crimes comprise about 88 per cent of all the male inmates paroled from the Washington State Penitentiary during 1927-32.

General inspection of Table I reveals a few obvious facts. One of these is the great variation of minimum sentences within most of the crimes considered and even within several of the subdivisions, the groups of previous records. Thus in Grand Larceny, no previous records, cases are found in each time interval up to eleven years. In Grand Larceny, two previous records, the actual range of minimum sentences extends from six months to life imprisonment. Such extremes are presumably justified because of varying factors involved, as the specific

[4] Even among the crimes with the largest totals the number of cases available in some subdivision within the crime, e. g., the group of two previous records in Robbery (16 cases), is frequently too small to constitute an adequate sampling when it would be desirable to consider such a group separately. However, it is sometimes justifiable to provide an adequate number of cases by combining certain cases or groups, such as all those in a given crime who have had previous commitments or all the cases from two or more crimes when such crimes have certain elements in common.

nature of the crime and the general character of the criminal, although the bases of determining minimum sentences may also vary considerably from court to court. The distribution of cases in Illegal Sale of Liquor is quite different from all the others in that all but two of the total 261 cases received minimum sentences between 1.0 and 2.9 years. The longest minimum in Illegal Sale of Liquor is only four years, and that occurs only once, whereas life imprisonment occurs twice in Robbery, twice in Carnal Knowledge and once in Grand Larceny, as already mentioned. Next to life imprisonment the longest minimum received is 25 years, which occurs twice in Robbery.

It should be noted, in order to understand better the distribution of sentences, that with the exception of those under one year most of the sentences received in each form of crime are full-year sentences. Thus in Grand Larceny, of the 292 cases who received minimum sentences between 1.0 and 1.9 years, 229, or 78.4 per cent, received exactly one year, and in Burglary, of the 123 cases who received minimum sentences between 2.0 and 2.9 years, 108, or 87.8 per cent, received exactly two years.

Another general fact revealed in Table I is that in most of the crimes the minimum sentence tends to be comparatively short. This is more clearly indicated in Table III by means of the frequencies which are expressed in percentages and also by means of the averages in the last column.[5] Thus in Grand Larceny, no previous records, 21.3 per cent received less than one year and exactly 50 per cent received from 1.0 to 1.9 years, which really means only one year for most of the cases. Also in this same group of no previous records, only a little more than 5 per cent received 5 years or more. The average for all the cases in this group is only 1.51 years. This preponderance of short minimum sentences is also indicated for practically all the different groups in Burglary, Forgery, Illegal Sale of Liquor, Assault and also in the less frequent crimes of Sodomy and Manslaughter. The largest percentage in each group is generally found in the time interval of 1.0 to 1.9 years. The column of the averages in Table III shows that in the four most

[5] Averages are used rather than medians because of the irregularities which occur in grouping all the different time intervals used to designate sentences. These irregularities are most evident in detailed distributions of sentences served and in the comparisons of one crime with another. Accordingly, the averages seem to indicate central tendencies about as accurately as the medians. In the periodical reports of the Bureau of the Census, U. S. Department of Commerce, relating to inmates in State and Federal penal institutions comparative measures of sentences are expressed in averages (see citations on following pages).

TABLE I

Frequency of different minimum sentences received in the more common forms of crime and according to previous records on the part of the male inmates paroled from the Washington State Penitentiary during the six-year period, 1927-32. Frequency is expressed by number of cases.

| | | Minimum sentences received | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Time in years | | | | | | | | | | |
| Crime | Previous Records | 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 4.9 | 5.0 to 5.9 | 6.0 to 6.9 | 7.0 to 8.9 | 9.0 to 10.9 | 11.0 to Life | Totals |
| Grand Larceny | 0 | 80 | 188 | 57 | 27 | 4 | 16 | 1 | 1 | 2 | | 376 |
| | 1 | 12 | 82 | 53 | 23 | 4 | 9 | | 1 | | | 184 |
| | 2 | 2 | 16 | 16 | 7 | 2 | 6 | | 1 | 1 | 1 | 52 |
| | 3* | | 6 | 2 | 3 | | 4 | | | | | 15 |
| | Totals | 94 | 292 | 128 | 60 | 10 | 35 | 1 | 3 | 3 | 1 | 627 |
| Burglary | 0 | 35 | 91 | 50 | 17 | 3 | 14 | | 4 | | | 214 |
| | 1 | 15 | 56 | 57 | 24 | 6 | 13 | 1 | 3 | 1 | 1 | 177 |
| | 2 | 5 | 18 | 13 | 8 | 2 | 12 | | 1 | | | 59 |
| | 3* | | 3 | 3 | 5 | 1 | 6 | | | 1 | 1 | 20 |
| | Totals | 55 | 168 | 123 | 54 | 12 | 45 | 1 | 8 | 2 | 2 | 470 |
| Forgery | 0 | 33 | 113 | 33 | 9 | 1 | 3 | | | | | 192 |
| | 1 | 12 | 33 | 33 | 19 | 4 | 11 | | 1 | | | 113 |
| | 2 | 8 | 16 | 12 | 6 | 3 | 3 | 1 | 1 | | | 50 |
| | 3* | 1 | 12 | 4 | 5 | | 6 | | | 1 | | 29 |
| | Totals | 54 | 174 | 82 | 39 | 8 | 23 | 1 | 2 | 1 | | 384 |
| Illegal Sale of Liquor | 0 | 1 | 212 | 11 | | | | | | | | 224 |
| | 1 | | 24 | 4 | | | | | | | | 28 |
| | 2 | | 5 | 1 | | 1 | | | | | | 7 |
| | 3* | | 1 | 1 | | | | | | | | 2 |
| | Totals | 1 | 242 | 17 | | 1 | | | | | | 261 |
| Robbery | 0 | | 1 | 7 | 3 | 1 | 99 | 3 | 22 | 17 | 4 | 157 |
| | 1 | | | 3 | | | 31 | 3 | 14 | 6 | 2 | 59 |
| | 2 | | | 1 | | | 9 | | 3 | | 3 | 16 |
| | 3* | | | | | | 1 | | 1 | | | 2 |
| | Totals | | 1 | 11 | 3 | 1 | 140 | 6 | 40 | 23 | 9 | 234 |
| Carnal Knowledge | 0 | 3 | 15 | 16 | 7 | 3 | 23 | 2 | 4 | 16 | 4 | 93 |
| | 1 | | 4 | 1 | 1 | | 2 | | | | 1 | 9 |
| | 2 | | | | | | 2 | | | | | 2 |
| | Totals | 3 | 19 | 17 | 8 | 3 | 27 | 2 | 4 | 16 | 5 | 104 |
| Assault | 0 | 17 | 23 | 10 | 3 | 2 | 10 | 1 | 1 | | 1 | 68 |
| | 1 | | 9 | | 2 | | 2 | | | | | 13 |
| | 2 | | 1 | 1 | 1 | | 1 | | | | | 4 |
| | 3 | | | | | | | | | | 1 | 1 |
| | Totals | 17 | 33 | 11 | 6 | 2 | 13 | 1 | 1 | | 2 | 86 |

* This should be interpreted as 3 or more previous records. There are, however, only a few cases with more than three previous records.

TABLE II

Frequency of different sentences actually served by the parolees referred to in Table I. Frequency is expressed by number of cases.

| Crime | Previous Records | Sentences served — Time in years: 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 4.9 | 5.0 to 5.9 | 6.0 to 6.9 | 7.0 to 8.9 | 9.0 to 10.9 | 11.0 or More | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 95 | 194 | 57 | 17 | 8 | 4 | | 1 | | | 376 |
| Grand | 1 | 13 | 83 | 54 | 24 | 3 | 5 | 1 | 1 | | | 184 |
| Larceny | 2 | 2 | 14 | 18 | 5 | 6 | 6 | | | 1 | | 52 |
| | 3* | | 3 | 5 | 3 | | 2 | 2 | | | | 15 |
| | Totals | 110 | 294 | 134 | 49 | 17 | 17 | 3 | 2 | 1 | | 627 |
| | 0 | 37 | 101 | 46 | 15 | 12 | 3 | | | | | 214 |
| | 1 | 17 | 56 | 63 | 23 | 5 | 9 | 1 | 2 | 1 | | 177 |
| Burglary | 2 | 3 | 16 | 17 | 8 | 2 | 10 | 2 | 1 | | | 59 |
| | 3* | | 1 | 3 | 5 | 1 | 5 | 4 | 1 | | | 20 |
| | Totals | 57 | 174 | 129 | 51 | 20 | 27 | 7 | 4 | 1 | | 470 |
| | 0 | 42 | 120 | 25 | 4 | | 1 | | | | | 192 |
| | 1 | 12 | 36 | 32 | 22 | 5 | 6 | | | | | 113 |
| Forgery | 2 | 6 | 17 | 13 | 5 | 4 | 4 | 1 | | | | 50 |
| | 3* | 1 | 10 | 4 | 4 | 4 | 5 | 1 | | | | 29 |
| | Totals | 61 | 183 | 74 | 35 | 13 | 16 | 2 | | | | 384 |
| Illegal | 0 | 31 | 189 | 3 | | 1 | | | | | | 224 |
| Sale of | 1 | | 24 | 4 | | | | | | | | 28 |
| Liquor | 2 | | 5 | 1 | | 1 | | | | | | 7 |
| | 3* | | 1 | 1 | | | | | | | | 2 |
| | Totals | 31 | 219 | 9 | | 2 | | | | | | 261 |
| | 0 | 1 | 13 | 35 | 21 | 27 | 41 | 9 | 6 | 4 | | 157 |
| | 1 | | 1 | 5 | 7 | 8 | 29 | | 4 | 3 | 2 | 59 |
| Robbery | 2 | | | 1 | 1 | 1 | 10 | | 3 | | | 16 |
| | 3* | | | | | | 1 | | 1 | | | 2 |
| | Totals | 1 | 14 | 41 | 29 | 36 | 81 | 9 | 14 | 7 | 2 | 234 |
| | 0 | 5 | 20 | 17 | 5 | 13 | 25 | 4 | | 3 | 1 | 93 |
| Carnal | 1 | | 5 | 1 | 1 | | | 1 | | | 1 | 9 |
| Knowledge | 2 | | | | | 1 | | 1 | | | | 2 |
| | Totals | 5 | 25 | 18 | 6 | 14 | 25 | 6 | | 3 | 2 | 104 |
| | 0 | 16 | 26 | 8 | 5 | 4 | 7 | 1 | 1 | | | 68 |
| | 1 | | 10 | | 1 | | 2 | | | | | 13 |
| Assault | 2 | | | 2 | 1 | | 1 | | | | | 4 |
| | 3 | | | | | | | | 1 | | | 1 |
| | Totals | 16 | 36 | 10 | 7 | 4 | 10 | 1 | 2 | | | 86 |

* This should be interpreted as 3 or more previous records. There are, however, only a few cases with more than three previous records.

## TABLE III

Relative frequencies of different minimum sentences received by various groups of parolees. Frequencies are expressed in percentages computed from the data in Table I and from the data of other types of crime.

| Crime | Previous Records | Number of Cases | Minimum sentences received — Time in years: 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 4.9 | 5.0 to 6.9 | 7.0 to 8.9 | 9.0 to Life | Average Time of Minimum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grand Larceny | 0 | 376 | 21.3 | 50.0 | 15.2 | 7.2 | 1.1 | 4.5 | 0.2 | 0.5 | 1.51 |
| | 1 | 184 | 6.5 | 44.6 | 28.8 | 12.5 | 2.2 | 4.9 | 9.5 | | 1.87 |
| | 2 | 52 | 3.8 | 30.8 | 30.8 | 13.5 | 3.8 | 11.5 | 1.9 | 3.8 | 2.92 |
| | 3* | 15 | | 40.0 | 13.3 | 20.0 | | 26.7 | | | 2.63 |
| Burglary | 0 | 214 | 16.4 | 42.5 | 23.4 | 7.9 | 1.4 | 6.5 | 1.9 | | 1.78 |
| | 1 | 177 | 8.5 | 31.6 | 32.2 | 13.6 | 3.4 | 7.9 | 1.7 | 1.1 | 2.28 |
| | 2 | 59 | 8.5 | 30.5 | 22.0 | 13.6 | 3.4 | 20.3 | 1.7 | | 2.54 |
| | 3* | 20 | | 15.0 | 15.0 | 25.0 | 5.0 | 30.0 | | 10.0 | 4.10 |
| Forgery | 0 | 192 | 17.2 | 58.9 | 17.2 | 4.7 | 0.5 | 1.5 | | | 1.33 |
| | 1 | 113 | 10.6 | 29.2 | 29.2 | 16.8 | 3.5 | 9.7 | 0.9 | | 2.18 |
| | 2 | 50 | 16.0 | 32.0 | 24.0 | 12.0 | 6.0 | 8.0 | 2.0 | | 2.09 |
| | 3* | 29 | 3.4 | 41.4 | 13.8 | 17.2 | | 20.7 | | 3.4 | 2.67 |
| Illegal Sale of Liquor | 0 | 244 | 0.5 | 94.6 | 4.9 | | | | | | 1.10 |
| | 1* | 37 | | 81.1 | 16.2 | | 2.7 | | | | 1.31 |
| Robbery | 0 | 157 | | 0.6 | 4.5 | 1.9 | 0.6 | 65.0 | 14.0 | 13.4 | 5.81 |
| | 1 | 59 | | | 5.1 | | | 57.6 | 23.7 | 13.6 | 6.42 |
| | 2* | 18 | | | 5.6 | | | 55.6 | 22.2 | 16.7 | 6.47 |
| Carnal Knowledge | 0 | 93 | 3.2 | 16.1 | 17.2 | 7.5 | 3.2 | 26.9 | 4.3 | 21.5 | 5.16 |
| | Total † | 104 | 2.9 | 18.3 | 16.3 | 7.7 | 2.9 | 27.9 | 3.8 | 20.2 | 5.04 |
| Assault | 0 | 68 | 25.0 | 33.8 | 14.7 | 4.4 | 2.9 | 16.2 | 1.5 | 1.5 | 2.20 |
| | Total † | 86 | 19.8 | 38.4 | 12.8 | 7.0 | 2.3 | 16.3 | 1.2 | 2.3 | 2.40 |
| Sodomy | 0 | 35 | 2.9 | 40.0 | 37.1 | 11.4 | | 5.7 | | 2.9 | 2.16 |
| | Total † | 45 | 4.4 | 44.4 | 33.3 | 8.9 | 2.2 | 4.4 | | 2.2 | 2.01 |
| Manslaughter | 0 | 33 | 6.1 | 24.2 | 24.2 | 9.1 | | 30.3 | 3.0 | 3.0 | 3.01 |
| | Total † | 40 | 5.0 | 20.0 | 27.5 | 10.0 | | 30.0 | 5.0 | 2.5 | 3.18 |
| Murder | 0 | 29 | | | 3.4 | | | | | 96.6 | 17.10 |
| | Total † | 32 | | | 3.1 | | | | | 96.9 | 17.37 |

* Numbers with an asterisk in the column of previous records should be interpreted as "3 or more previous records," "1 or more previous records," etc.

† "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

TABLE IV

Relative frequencies of different sentences served by various groups of parolees. Frequencies are expressed in percentages computed from the data in Table II and from the data of other types of crime.

| Crime | Previous Records | Number of Cases | Sentences served — Time in years: 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 4.9 | 5.0 to 6.9 | 7.0 to 8.9 | 9.0 or More | Average Time Served |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Grand Larceny | 0 | 376 | 25.3 | 51.6 | 15.1 | 4.5 | 2.1 | 1.1 | 0.3 | | 1.31 |
| | 1 | 184 | 7.1 | 45.2 | 29.3 | 13.0 | 1.6 | 3.3 | 0.3 | | 1.76 |
| | 2 | 52 | 3.8 | 26.9 | 34.6 | 9.6 | 11.5 | 11.5 | | 1.9 | 2.61 |
| | 3* | 15 | | 20.0 | 33.3 | 20.0 | | 26.7 | | | 3.12 |
| Burglary | 0 | 214 | 17.3 | 47.2 | 21.5 | 7.0 | 5.6 | 1.4 | | | 1.54 |
| | 1 | 177 | 9.6 | 31.6 | 35.6 | 13.0 | 2.8 | 5.6 | 1.1 | 0.6 | 2.17 |
| | 2 | 59 | 5.1 | 27.1 | 28.8 | 13.6 | 3.4 | 20.3 | 1.7 | | 2.71 |
| | 3* | 20 | | 5.0 | 15.0 | 25.0 | 5.0 | 45.0 | 5.0 | | 4.29 |
| Forgery | 0 | 192 | 21.9 | 62.5 | 13.0 | 2.1 | | 0.5 | | | 1.17 |
| | 1 | 113 | 10.6 | 31.9 | 28.3 | 19.5 | 4.4 | 5.3 | | | 2.02 |
| | 2 | 50 | 12.0 | 34.0 | 26.0 | 10.0 | 8.0 | 10.0 | | | 2.18 |
| | 3* | 29 | 3.4 | 34.5 | 13.8 | 13.8 | 13.8 | 20.7 | | | 2.84 |
| Illegal Sale of Liquor | 0 | 224 | 13.8 | 84.4 | 1.3 | | 0.5 | | | | 1.01 |
| | 1* | 37 | | 81.1 | 16.2 | | 2.7 | | | | 1.34 |
| Robbery | 0 | 157 | 0.6 | 8.3 | 22.3 | 13.4 | 17.2 | 31.8 | 3.8 | 2.5 | 3.99 |
| | 1 | 59 | | 1.7 | 8.5 | 11.9 | 13.5 | 49.2 | 6.8 | 8.5 | 5.06 |
| | 2* | 18 | | | 5.6 | 5.6 | 5.6 | 61.1 | 22.2 | | 5.32 |
| Carnal Knowledge | 0 | 93 | 5.4 | 21.5 | 18.3 | 5.4 | 14.0 | 31.2 | | 4.3 | 3.40 |
| | Total † | 104 | 4.8 | 24.0 | 17.3 | 5.8 | 13.5 | 29.8 | | 4.8 | 3.44 |
| Assault | 0 | 68 | 23.5 | 38.2 | 11.8 | 7.4 | 5.9 | 11.8 | 1.5 | | 1.96 |
| | Total † | 86 | 18.6 | 41.9 | 11.6 | 8.1 | 4.7 | 12.8 | 2.3 | | 2.08 |
| Sodomy | 0 | 35 | 5.7 | 34.3 | 40.0 | 11.4 | | 8.6 | | | 2.03 |
| | Total † | 45 | 4.4 | 33.3 | 44.4 | 8.9 | 2.2 | 6.7 | | | 2.02 |
| Manslaughter | 0 | 33 | 9.1 | 21.2 | 39.4 | 15.1 | 9.1 | 6.1 | | | 2.35 |
| | Total † | 40 | 7.5 | 17.5 | 40.0 | 17.5 | 7.5 | 10.0 | | | 2.56 |
| Murder | 0 | 29 | | | 6.9 | | 3.4 | 27.6 | 17.2 | 44.8 | 8.71 |
| | Total † | 32 | | | 6.3 | | 3.1 | 25.0 | 18.7 | 46.9 | 9.09 |

* Numbers with an asterisk in the column of previous records should be interpreted as "3 or more previous records," "1 or more previous records," etc.

† "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

frequent crimes the averages for the group of no previous records range from 1.10 years for Illegal Sale of Liquor to 1.78 years for Burglary, and even in groups of two or more previous records they are in all but one case under three years.

Robbery and Murder are outstanding exceptions to the foregoing. In each of the three groups in Robbery (Table III), over 90 per cent receive a minimum of 5 years or more with averages of 5.81, 6.42, and 6.47. In Murder, although the total number of cases is small (32 cases), only one inmate received a minimum below that of the highest interval (actually 2 years), whereas thirteen received life imprisonment, two received 25 years and three others received over 10 years, the average for the whole group being 17.37 years.[6] Carnal Knowledge differs also from most of the other crimes with respect to the distribution of its cases and its comparatively high averages: 5.16 and 5.04 years.

A third general fact which is indicated in Table I and more clearly indicated by the averages in Table III is that the minimum sentence tends to increase in length with the number of previous records. There are a few exceptions to this tendency, but at least some of these exceptions may be due to inadequate samplings. It is obvious, however, that some cases with two or more previous records receive minimum sentences of less duration than do others with no previous records. Such variations in sentences received are at least partly accounted for by varying combinations of factors which are peculiar to each case.

Though the minimum sentence is of importance as an expression of the significance attached to a crime, the sentence actually served is at least intended to be a truer measure of the inmate's criminal status and particularly of his fitness for parole. It is, therefore, necessary to consider the sentences served by various groups of inmates and also compare sentences served with minimum sentences received. Table II is thus presented to show the distribution of sentences actually served by the same groups of inmates as are considered in Table I.

The general facts revealed in Table I are evidenced also in Table II: considerable variation of sentences within each group, the preponderance of relatively short sentences in most of the groups, and a tendency for the distributions to vary according to the number of previous records. But a close inspection of Tables I and II will show certain differences between sentences served and sentences received.

[6] In the computation of averages for groups where life sentences occur, each such sentence is arbitrarily regarded as 25 years.

These differences, however, can be more clearly indicated by noting the percentages in Tables III and IV and also by the averages included in these tables. For example, a comparison of the two sets of percentages shows, for the groups of no previous records and one previous record, that the number of short sentences served is greater than the number of short minimum sentences received. Thus also the number serving sentences in the longer intervals of time is correspondingly less than the number receiving sentences in the same intervals of time. The specific differences are generally small, but they occur quite uniformly in all of the crimes indicated. The reverse trend is evidenced to a slight degree in groups having two or more previous records, although it does not occur so regularly as the differences noted in the groups with one and no previous records.

The differences in the two sets of distributions, presented in Tables I and II and also in Tables III and IV, are obviously reflected in the averages, included in the latter two tables. Hence these averages of themselves offer a convenient though rough basis for comparing the two types of sentences. When corresponding averages are compared directly with each other, they reveal a variety of differences. Although many of these differences are too small to be statistically valid, it is of some significance to note that the average sentence served by each group of one or no previous records is in every instance of less duration than the corresponding time indicating the average minimum received. Although some in these groups have had their sentences increased (as will be shown in later tables), this is more than offset by the extent of decreases, so that the total effect is to make the sentence served less, on the average, than the minimum sentence received. The trend in the groups of two or more previous records is somewhat the reverse of that in the other groups, although there are some exceptions.

The most marked reductions in time served in comparison with time received occur in Robbery, Carnal Knowledge, and Murder. In Robbery the average reduction is almost two years in the group of no previous records. In Carnal Knowledge it is a little over one and one-half years. In Murder, although thirty-one of the total thirty-two cases received 10 years or more and thirteen received sentences for life, only nine of the sentences served were over 10 years and two of these nine were for 10½ years. The longest sentence served by any one in this particular group is 19½ years. Whether such reductions in sentences received are advantageous to society is, of course, one of the important

questions to be considered. Data to be presented in succeeding tables will have some bearing on this problem.

Averages of minimum sentences received and sentences served by parolees from Washington State Penitentiary in each of several crimes may be compared with corresponding data on parolees from State and Federal penal institutions. The most comparable data available are presented in an official report for 1931 and 1932[7] which relates particularly to prisoners in State and Federal penitentiaries and reformatories who were released during the year 1931. Table V presents the most pertinent data on the parolees who received indeterminate sentences and who were convicted for the crimes which at least in name correspond most closely to those considered in this study. The table also includes averages of sentences served by State and Federal prisoners who were discharged in 1936; these are presented in the latest report available,[8] but the average minimum sentences are not included in this report. Each report from the Bureau of the Census apparently includes all cases together without regard for variation in previous records; accordingly, the averages presented for Washington State Penitentiary are also for each criminal group as a whole.

The table shows that in each crime listed the average minimum received by the State and Federal parolees is less than that received by the Washington parolees. The average time served by the State and Federal parolees (1931), however, is longer than that served by parolees in Washington except for Illegal Sale of Liquor and for Robbery. The differences in the first set of averages range from 0.9 years to 1.43 years, and in the second set from 0.6 years to 0.58 years. The order of the crimes from the one with the shortest average minimum to the longest average minimum is the same for each of the two groups and is as follows: Illegal Sale of Liquor, Grand Larceny, Forgery, Burglary, Assault, and Robbery; and the order for average time served is essentially the same. The data for 1936 show that for each crime except Robbery the average time served is less than what was required in 1931.

The tables thus far have presented data on parolees without regard for parole status. It is, therefore, necessary to note whether the sentences served by violators are in any way different from those served

[7] *Prisoners in State and Federal Prisons and Reformatories*, 1931 and 1932, U. S. Department of Commerce, Bureau of the Census (Government Printing Office, Washington, D.C.), p. 36.

[8] *Ibid.*, 1936, p. 51.

TABLE V

Data on sentences received and served by the parolees from Washington State Penitentiary and by those released from State and Federal penitentiaries and reformatories in 1931, including averages for time served by the State and Federal parolees released in 1936. All averages are expressed in years although in the reports of the Bureau of Census the averages are expressed in months.

| Crime | Average Minimum Received | | Average Sentence Served | | |
|---|---|---|---|---|---|
| | Wash. State Pen. | State and Federal 1931 | Wash. State Pen. | State and Federal 1931 | State and Federal 1936 |
| Grand Larceny | 1.76 | 1.32 | 1.61 | 1.98 | 1.54* |
| Burglary | 2.16 | 1.78 | 2.09 | 2.31 | 2.16 |
| Forgery | 1.78 | 1.38 | 1.68 | 2.10 | 1.86 |
| Illegal Sale of Liquor | 1.13 | 1.04 | 1.06 | 1.00 | 0.84 |
| Robbery | 6.01 | 4.58 | 4.36 | 3.78 | 3.90 |
| Assault | 2.40 | 2.12 | 2.08 | 2.51 | 2.23† |

* For Larceny excluding Auto Theft. The average for Auto Theft is 2.00 years.
† For Aggravated Assault. The average for Other Assault is 1.28 years.

by non-violators. Tables VI and VII, and also some of the succeeding tables, deal with this phase of the problem. Table VI shows the frequency of sentences served by the violators in ten different crimes along with averages of sentences served by both violators and non-violators. The less frequent crimes of Sodomy, Manslaughter, and Murder are included in Table VI to show the extent and the trend of violation in these offenses, although there are only a few cases in each. The averages of time served are omitted for these crimes because of the small number of cases.

Table VI may be compared with Table II and where allowance is made for the differences in grouping of time intervals it becomes evident that there is considerable similarity in corresponding groups with reference to distribution of cases. This is especially true in such frequent crimes as Grand Larceny, Burglary, Forgery, and Robbery. Thus the sentences which violators as a group are required to serve are not clearly distinguished from those required of the larger group composed of both violators and non-violators. The differences which do exist

## TABLE VI

Frequency of different sentences actually served by those parolees included in Table IV who are classed as violators. Frequency is expressed by number of cases. Averages of time served by different groups of violators and non-violators are also presented.

| Crime | Previous Records | Sentences served: Time in years 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 4.9 | 5.0 to 6.9 | 7.0 to 8.9 | 9.0 or More | Total Number of Violators | Average Time Served: Viol. | Non. | Difference in Time Served |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grand Larceny | 0 | 21 | 60 | 26 | 8 | 2 | 2 | 1 | | 120 | 1.52 | 1.22 | .30 |
| | 1 | 6 | 32 | 27 | 9 | 1 | 3 | | | 78 | 1.77 | 1.86 | —.09 |
| | 2 | | 11 | 9 | | 4 | 2 | | 1 | 27 | 2.59 | 2.70 | —.11 |
| | 3* | | 1 | 3 | 3 | | 4 | | | 11 | 3.65 | 1.63 | 2.02 |
| Burglary | 0 | 12 | 47 | 19 | 6 | 4 | 2 | | | 90 | 1.57 | 1.52 | .05 |
| | 1 | 9 | 31 | 39 | 17 | 2 | 3 | 2 | 1 | 104 | 2.22 | 2.09 | .13 |
| | 2 | 2 | 12 | 12 | 6 | 2 | 8 | | | 42 | 2.64 | 2.90 | —.26 |
| | 3* | | 1 | 2 | 3 | 1 | 6 | 1 | | 14 | 4.30 | 4.25 | .05 |
| Forgery | 0 | 16 | 44 | 9 | 1 | | 1 | | | 71 | 1.11 | 1.21 | —.10 |
| | 1 | 4 | 16 | 16 | 15 | 4 | 2 | | | 57 | 2.18 | 1.84 | .34 |
| | 2 | 4 | 14 | 8 | 2 | 4 | 4 | | | 36 | 2.26 | 2.00 | .26 |
| | 3* | 1 | 5 | 3 | 1 | 3 | 5 | | | 18 | 3.15 | 2.32 | .83 |
| Illegal Sale of Liquor | 0 | | 16 | | | 1 | | | | 17 | 1.22 | 1.00 | .22 |
| | 1* | | 5 | 1 | | 1 | | | | 7 | 1.79 | 1.23 | .56 |
| Robbery | 0 | | 2 | 14 | 3 | 12 | 26 | 3 | 2 | 62 | 4.43 | 3.71 | .72 |
| | 1 | | | 2 | 3 | 4 | 15 | 2 | 4 | 30 | 5.54 | 4.54 | 1.00 |
| | 2* | | | 1 | | | 8 | 4 | | 13 | 5.62 | 4.55 | 1.07 |
| Carnal Knowledge | 0 | | 2 | 3 | | 3 | 3 | | | 11 | 3.18 | 3.43 | —.25 |
| | Total† | | 2 | 3 | | 4 | 4 | | | 13 | 3.46 | 3.44 | .02 |
| Assault | 0 | 5 | 7 | | 1 | | 1 | 1 | | 15 | 1.72 | 2.07 | —.35 |
| | Total† | 5 | 11 | 1 | 2 | | 3 | 2 | | 24 | 2.17 | 2.04 | .13 |
| Sodomy | 0 | | 2 | 4 | 1 | | 1 | | | 8 | | | |
| | Total† | | 4 | 9 | 1 | 1 | 1 | | | 16 | | | |
| Manslaughter | 0 | 1 | 1 | 3 | | | | | | 5 | | | |
| | Total† | 1 | 1 | 4 | 1 | | | | | 7 | | | |
| Murder | 0 | | | | | | 3 | | 3 | 6 | | | |
| | Total† | | | | | | 3 | 1 | 1 | 7 | | | |

* Numbers with an asterisk in the column of previous records should be interpreted as "3 or more previous records," "1 or more previous records," etc.

† "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

TABLE VII

Frequencies of different sentences served by violators and non-violators. Frequencies are expressed in percentages.

| Crime | Previous Records | Status of Parole | Number of Cases | Sentences served, Time in years: 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 to 5.9 | 6.0 or More | Av. Time of Minimum | Av. Time Served | Difference in Averages |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Viol. | 120 | 17.5 | 50.0 | 21.7 | 6.7 | 3.3 | 0.8 | 1.66 | 1.52 | .14 |
| Grand | 0 | Non. | 256 | 28.9 | 52.3 | 12.1 | 3.5 | 3.1 | | 1.44 | 1.22 | .22 |
| | | Viol. | 78 | 7.7 | 41.0 | 34.6 | 11.5 | 5.1 | | 1.79 | 1.77 | .02 |
| Larceny | 1 | Non. | 106 | 6.6 | 48.1 | 25.5 | 14.2 | 3.8 | 1.9 | 1.93 | 1.86 | .07 |
| | | Viol. | 38 | | 31.6 | 31.6 | 7.9 | 21.1 | 7.9 | 3.13 | 2.85 | .28 |
| | 2* | Non. | 29 | 6.9 | 17.2 | 37.9 | 17.2 | 20.7 | | 2.50 | 2.56 | —.06 |
| | | Viol. | 90 | 13.3 | 52.2 | 21.1 | 6.7 | 6.7 | | 1.76 | 1.57 | .19 |
| | 0 | Non. | 124 | 20.2 | 43.5 | 21.8 | 7.3 | 7.3 | | 1.79 | 1.52 | .27 |
| | | Viol. | 104 | 8.7 | 29.8 | 37.5 | 16.3 | 4.8 | 2.9 | 2.28 | 2.22 | .06 |
| Burglary | 1 | Non. | 73 | 11.0 | 34.2 | 32.9 | 8.2 | 12.3 | 1.4 | 2.28 | 2.09 | .19 |
| | | Viol. | 56 | 3.6 | 23.2 | 25.0 | 16.1 | 23.2 | 8.9 | 2.89 | 3.06 | —.17 |
| | 2* | Non. | 23 | 4.3 | 17.4 | 26.1 | 17.4 | 21.7 | 13.0 | 3.03 | 3.25 | —.22 |
| | | Viol. | 71 | 22.5 | 62.0 | 12.7 | 1.4 | 1.4 | | 1.29 | 1.11 | .18 |
| | 0 | Non. | 121 | 21.5 | 62.8 | 13.2 | 2.5 | | | 1.36 | 1.21 | .15 |
| | | Viol. | 57 | 7.0 | 28.1 | 28.1 | 26.3 | 10.5 | | 2.29 | 2.18 | .11 |
| Forgery | 1 | Non. | 56 | 14.3 | 35.7 | 28.6 | 12.5 | 8.9 | | 2.06 | 1.84 | .22 |
| | | Viol. | 54 | 9.3 | 35.2 | 20.4 | 5.5 | 25.9 | 3.7 | 2.34 | 2.56 | —.22 |
| | 2* | Non. | 25 | 8.0 | 32.0 | 24.0 | 24.0 | 12.0 | | 2.22 | 2.14 | .08 |
| | | Viol. | 17 | | 94.1 | | | 5.9 | | 1.15 | 1.22 | —.07 |
| Illegal | 0 | Non. | 207 | 15.0 | 83.6 | 1.4 | | | | 1.10 | 1.00 | .10 |
| Sale of | | Viol. | 24 | | 87.5 | 4.2 | | 8.3 | | 1.31 | 1.39 | —.08 |
| Liquor | Total† | Non. | 237 | 13.1 | 83.5 | 3.4 | | | | 1.11 | 1.03 | .08 |
| | | Viol. | 62 | | 3.2 | 22.6 | 4.8 | 53.2 | 16.1 | 5.71 | 4.43 | 1.28 |
| | 0 | Non. | 95 | 1.1 | 11.6 | 22.1 | 18.9 | 36.8 | 9.5 | 5.87 | 3.71 | 2.16 |
| Robbery | | Viol. | 43 | | | 7.0 | 7.0 | 62.8 | 23.2 | 6.87 | 5.56 | 1.31 |
| | 1* | Non. | 34 | | 2.9 | 8.8 | 14.7 | 64.7 | 8.8 | 6.13 | 4.57 | 1.56 |
| | | Viol. | 11 | | 18.2 | 27.3 | | 54.5 | | 3.45 | 3.18 | .27 |
| Carnal | 0 | Non. | 82 | 6.1 | 22.0 | 17.1 | 6.1 | 39.0 | 9.7 | 5.39 | 3.43 | 1.96 |
| Knowledge | | Viol. | 13 | | 15.4 | 23.1 | | 53.8 | 7.6 | 3.69 | 3.46 | .23 |
| | Total† | Non. | 91 | 5.5 | 25.3 | 16.5 | 6.6 | 35.2 | 11.0 | 5.23 | 3.44 | 1.79 |
| | | Viol. | 15 | 33.3 | 46.7 | | 6.7 | 6.7 | 6.7 | 1.65 | 1.72 | —.07 |
| | 0 | Non. | 53 | 20.8 | 35.8 | 15.1 | 7.5 | 18.9 | 1.9 | 2.36 | 2.07 | .29 |
| Assault | | Viol. | 23 | 21.7 | 47.8 | 4.3 | 8.7 | 13.0 | 4.3 | 2.64 | 2.17 | .47 |
| | Total† | Non. | 63 | 17.5 | 39.7 | 14.3 | 7.9 | 17.5 | 3.2 | 2.31 | 2.04 | .27 |

* Numbers with an asterisk in the column of previous records should be interpreted as "2 or more previous records," "1 or more previous records," etc.

† "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

may be more clearly noted by means of the percentages and averages provided in Table VII along with the averages presented in Table VI. The percentages in Table VII, which indicate distribution of sentences, also reveal considerable similarity between the two groups compared, but some differences can be noted in the shorter sentences. Here the non-violators have quite consistently higher percentages except in Forgery and Assault. The effect of this tendency along with less obvious variations is reflected in the column in Table VII, showing average time served. A similar set of averages for both violators and non-violators is presented in Table VI along with the differences between the two groups. According to Table VI, only six groups of violators have served a shorter average sentence than did the corresponding groups of non-violators, whereas in the other fifteen groups the violators served the longer average sentence. The figures in Table VII show, of course, a similar trend. In several groups the differences are rather small, but where the larger differences occur, such as half a year or more (more clearly seen in Table VI), it is the violators who have the larger average. When averages of sentences served are obtained for each crime with all cases in each considered together, such averages are consistently higher for the violator than for the non-violator in each of the seven most frequent crimes.

The averages of minimum sentences received, presented in Table VII, show no consistent differences in favor of either violators or non-violators except in Carnal Knowledge, where the small number of violators were favored with sentences distinctly shorter than those which the non-violators received. In only five instances, including the two in Carnal Knowledge, are the differences as great as one-half year.

A comparison of time served with the minimum sentences received shows that in most instances both violators and non-violators serve on the average less time than that indicated by the minimum. Except in Robbery and Carnal Knowledge, most of the differences, presented in Table VII, are small; and this is particularly true in the few instances where the average time served exceeded the average of the minimum. The few cases which show the larger differences are the ones that received the longest sentences in the first place.

The relation of frequency of violation to length of sentence served is dealt with in Tables VIII and IX, with the more detailed data presented in Table VIII. To present the situation as clearly as possible (in Table VIII), the sentences are first grouped into five intervals of

time—a grouping which still permits of fairly adequate sampling in most of the intervals for several groups of parolees. Then two other groupings are presented with only two intervals of time represented in each—with the points of division placed at three years in the one case and at two years in the other case. The latter two groupings have the effect of classifying all sentences as short or long, and at the same time they provide a fairly well-balanced distribution of cases; they also make possible larger samplings for more groups of parolees than is possible when more intervals are used.

In each of the three arrangements of the data the general fact is revealed that violation is generally more frequent in the longer sentences than in the shorter ones. This is more clearly indicated by the totals for each crime and especially by the totals in Grand Larceny, Burglary, Forgery, and Robbery—four crimes which occur with considerable frequency. According to the two two-interval classifications described above, the increase in violation is not marked—the largest increase being 19.6 per cent, which occurs in Forgery; only four groups show an increase over 10 per cent in the one classification, and only three groups in the other. Furthermore, as revealed in the five-interval arrangement, there is in general no uniform increase in violation with increase in length of sentence, and the relationship varies with the crime and with difference in previous records. For example, in the totals for Grand Larceny the rate at the interval representing the longest sentences is but little greater than at the two-year interval, and the rate at the three-year interval is less than that at the two-year interval. In Burglary the more complete data show quite a marked increase in violation up to the three-year interval, but there is a definite decline in the rate for the interval with the longest sentences. The more complete data for Forgery show the most consistent increase in rate of violation throughout the five intervals—with an increase of 33.1 per cent from the group of shortest sentences to the longest. In Assault—with its comparatively small number of cases—the more complete data indicate a tendency which is the reverse of that of the other crimes, and Robbery also shows some irregularity. Illegal Sale of Liquor, which has a very low rate of violation in its various groups, has no violation whatever among the cases (31) with sentences under one year.

The last column of Table VIII reveals considerable variation in violation among the different crimes, although with the exception of Illegal Sale of Liquor all of the most frequent crimes—Grand Larceny,

TABLE VIII

Percentage of violation in different sentences served by various groups of inmates. Percentages marked with an "*" are based on totals between 20 and 40. Percentages are omitted where the number of cases is less than 20.

| | | Sentences served Time in years | | | | | Sentences served Time in years | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crime | Previous Records | 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 3.9 | 4.0 or More | 0.0 to 2.9 | 3.0 or More | 0.0 to 1.9 | 2.0 or More | Total for all Sentences |
| | 0 | 22.1 | 30.9 | 45.6 | | | 30.9 | 43.3* | 28.0 | 44.8 | 31.9 |
| Grand | 1† | | 44.0 | 50.7 | 37.5* | 55.6* | 46.4 | 45.8 | 43.5 | 48.5 | 46.3 |
| Larceny | Total‡ | 24.5 | 35.4 | 48.5 | 40.8 | 50.0 | 36.4 | 44.7 | 32.4 | 47.1 | 37.6 |
| | 0 | 32.4* | 46.5 | 41.3 | | | 42.4 | 40.0* | 42.8 | 40.8 | 42.1 |
| | 1† | 55.0* | 60.3 | 63.9 | 72.2* | 59.1 | 61.4 | 65.0 | 59.1 | 64.4 | 62.5 |
| Burglary | Total‡ | 40.4 | 52.3 | 55.8 | 62.7 | 54.2 | 51.7 | 58.2 | 49.4 | 56.9 | 53.2 |
| | 0 | 38.1 | 36.7 | 36.0* | | | 36.9 | | 37.0 | 34.4 | 37.0 |
| | 1† | | 55.5 | 55.1 | 58.1* | 73.3* | 54.2 | 65.6 | 53.7 | 60.9 | 57.8 |
| Forgery | Total‡ | 40.9 | 43.6 | 48.8 | 54.3* | 74.2* | 44.0 | 63.6 | 42.6 | 55.7 | 47.4 |
| Illegal | 0 | 0.0* | 8.4 | | | | 7.1 | | 7.3 | | .76 |
| Sale of | 1† | | 16.7* | | | | 16.7* | | 16.7* | | 18.9* |
| Liquor | Total‡ | 0.0* | 9.6 | | | | 8.5 | | 8.0 | | 9.2 |
| | 0 | | | 42.9* | 14.3* | 49.4 | 32.7 | 42.6 | | 42.0 | 39.5 |
| | 1† | | | | | 60.0 | | 57.1 | | 56.6 | 55.8 |
| Robbery | Total‡ | | | 43.9 | 20.7* | 53.7 | 33.9 | 48.3 | | 47.0 | 44.9 |
| Carnal | 0 | | 10.0* | | | 13.0 | 11.9 | 11.8 | 8.0* | 13.2 | 11.8 |
| Knowledge | Total‡ | | 8.0* | | | 16.0 | 20.8 | 14.3 | 6.7* | 14.9 | 12.5 |
| | 0 | | 26.9* | | | | 24.0 | | 28.6 | 11.5* | 22.1 |
| Assault | Total‡ | | 30.6* | | | | 27.4 | 29.4 | 30.8 | 23.5* | 27.9 |

† One or more previous records.
‡ "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

Burglary, Forgery, and Robbery—have a comparatively high percentage of violation. Also in the five most frequent crimes there is a distinctly higher rate of violation in the groups with previous records than in those without previous records and, as has been noted in previous tables, it is the groups with previous records that are required to serve the longer sentences.

In order that the relation of percentage of violation to sentence served may be shown more accurately by providing larger numbers of cases, the results for Grand Larceny, Burglary, Forgery, and Robbery are presented together in Table IX, first with an arrangement of five intervals of time and then one of three intervals. The four crimes to-

gether include about 70 per cent of all parolees for the period under consideration and, as revealed in Table VIII, their percentages of violation are very similar.

Though some irregularities still appear, most noticeably at the interval of 3.0 to 4.9 years, the general fact revealed in Table VIII is now more clearly indicated in each set of previous records in Table IX; that is, the rate of violation is greater for the longer sentences than for the shorter sentences. This is best indicated by the differences in rates of violation between the two extremes of the scale of intervals. In the five-interval arrangement, which covers a range of over four years, the difference amounts to 25.2 per cent between the totals which represent the percentages of violation for the shortest and the longest sentences.

TABLE IX

Percentage of violation in different sentences served by the inmates in four crimes considered together—Grand Larceny, Burglary, Forgery, and Robbery.

| Previous Records | Sentences served Time in years | | | | | Sentences served Time in years | | | Total for all Sentences |
|---|---|---|---|---|---|---|---|---|---|
| | 0.0 to 0.9 | 1.0 to 1.9 | 2.0 to 2.9 | 3.0 to 4.9 | 5.0 or More | 0.0 to 1.9 | 2.0 to 3.9 | 4.0 or More | |
| 0 | 28.0 | 35.7 | 41.7 | 34.6 | 53.6 | 33.5 | 39.1 | 47.4 | 36.5 |
| 1 | 45.2 | 44.9 | 54.5 | 56.7 | 50.0 | 45.0 | 55.7 | 50.6 | 50.1 |
| 2* | 58.3 | 72.1 | 62.3 | 59.2 | 71.7 | 69.9 | 57.6 | 73.1 | 66.3 |
| Total† | 32.8 | 41.5 | 50.3 | 48.0 | 58.0 | 39.3 | 49.3 | 55.6 | 45.1 |

* Two or more previous records.
† "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

Another approach to the relation of length of sentence to violation may be made by resort to other groupings of sentences than those used in the foregoing tables. Instead of grouping sentences served according to specific time intervals, one might classify them in three groups as follows: one group is to include the persons who are released at the end of the minimum sentence, a second group is to include those who are released before the expiration of the minimum, and the third group is to include those who are required to serve a sentence somewhat longer than the minimum received. These three groups will hereafter be referred to as Groups A, B, and C, respectively, and tables will be presented showing differences between the groups, such as differences

in frequency of cases, percentage of violation, minimum sentences received and sentences served.

Table X presents, in one section, the number of parolees in each of the three groups classified according to crime and previous records, and in another section it presents the number of violators and nonviolators in each group. The distribution by totals shows clearly that in each crime except Robbery the largest number of cases is to be found in Group A, and the least number in Group C, with Group B only slightly larger than Group C. In Robbery the largest number is to be found in Group B, and, as in the other crimes, the smallest number is in Group C. The specific proportions in each group, as arranged by crime and previous records, are better indicated by the percentages presented in Table XI.

Attention to the totals in Table XI, which indicates the distribution in Groups A, B, and C by percentages, reveals that the distributions are quite similar in Grand Larceny, Burglary, Forgery, and Assault. In each of these crimes, Group A contains a little over 70 per cent of the cases; the number in Group B ranges between 14.5 per cent and 17.4 per cent, and in Group C the range is from 8.9 per cent to 13.2 per cent. Of the seven crimes listed, Illegal Sale of Liquor has the largest percentage in Group A, 80.8, and Robbery has the smallest, 33.8 per cent. Burglary has the largest percentage in Group C, 13.2, and Illegal Sale of Liquor the smallest, 1.9 per cent. In Robbery 62.8 per cent and in Carnal Knowledge 35.6 per cent are released before the expiration of the minimum. As revealed in Table III, however, the inmates convicted of either of these two crimes are the ones who are likely to receive relatively long sentences.

Among the cases with no previous records, the numbers found in Group C are rather small, the highest percentage, 10.3, being in Assault. But the percentage in Group C increases markedly for those with one or more previous records. In this latter division, 23 per cent of the burglars are required to serve sentences beyond the minimum. In Group B the reverse trend is evident if the frequency of those having no previous records is compared with those having one or more previous records. The percentage for Robbery drops from 71.3 to 45.4, and for Illegal Sale of Liquor from 19.6 to 2.7.

Because of the manner in which the cases are distributed in Groups A, B, and C, it is necessary to note whether there are variations in the sentences received and in sentences served. Though the data are in-

TABLE X

Number of parolees in the more common types of crime who served the minimum sentence (called Group A), those who served less than the minimum stentence (called Group B), and those who served more than the minimum stenence (called Group C). Numbers of violators and non-violators in each of the three groups are also presented separately.

| Crime | Previous Records | Group A | Group B | Group C | Total Number of Cases | Group A | | Group B | | Group C | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Viol. | Non. | Viol. | Non. | Viol. | Non. |
| Grand Larceny | 0 | 297 | 66 | 13 | 376 | 93 | 204 | 18 | 48 | 9 | 4 |
| | 1 | 145 | 17 | 22 | 184 | 63 | 82 | 4 | 13 | 11 | 11 |
| | 2 | 31 | 8 | 13 | 52 | 14 | 17 | 5 | 3 | 8 | 5 |
| | 3* | 7 | | 8 | 15 | 5 | 2 | | | 6 | 2 |
| | Totals | 480 | 91 | 56 | 627 | 175 | 305 | 27 | 64 | 34 | 22 |
| Burglary | 0 | 171 | 40 | 3 | 214 | 76 | 95 | 13 | 27 | 1 | 2 |
| | 1 | 121 | 26 | 30 | 177 | 73 | 48 | 11 | 15 | 20 | 10 |
| | 2 | 39 | 1 | 19 | 59 | 27 | 12 | | 1 | 15 | 4 |
| | 3* | 8 | 2 | 10 | 20 | 6 | 2 | 2 | | 6 | 4 |
| | Totals | 339 | 69 | 62 | 470 | 182 | 157 | 26 | 43 | 42 | 20 |
| Forgery | 0 | 149 | 37 | 6 | 192 | 57 | 92 | 11 | 26 | 3 | 3 |
| | 1 | 87 | 17 | 9 | 113 | 44 | 43 | 7 | 10 | 6 | 3 |
| | 2 | 34 | 3 | 13 | 50 | 21 | 13 | 2 | 1 | 13 | |
| | 3* | 15 | 1 | 13 | 29 | 6 | 9 | 1 | | 11 | 2 |
| | Totals | 285 | 58 | 41 | 384 | 128 | 157 | 21 | 37 | 33 | 8 |
| Illegal Sale of Liquor | 0 | 179 | 44 | 1 | 224 | 15 | 164 | 1 | 43 | 1 | |
| | 1 | 26 | 1 | 1 | 28 | 4 | 22 | | 1 | | 1 |
| | 2 | 5 | | 2 | 7 | 1 | 4 | | | 1 | 1 |
| | 3* | 1 | | 1 | 2 | | 1 | | | 1 | |
| | Totals | 211 | 45 | 5 | 261 | 20 | 191 | 1 | 44 | 3 | 2 |
| Robbery | 0 | 42 | 112 | 3 | 157 | 23 | 19 | 37 | 75 | 2 | 1 |
| | 1 | 28 | 29 | 2 | 59 | 12 | 16 | 16 | 13 | 2 | |
| | 2 | 9 | 6 | 1 | 16 | 7 | 2 | 3 | 3 | 1 | |
| | 3* | | | 2 | 2 | | | | | 2 | |
| | Totals | 79 | 147 | 8 | 234 | 42 | 37 | 56 | 91 | 7 | 1 |
| Carnal Knowledge | 0 | 52 | 35 | 6 | 93 | 7 | 45 | 2 | 33 | 2 | 4 |
| | 1 | 7 | 1 | 1 | 9 | | 7 | | 1 | 1 | |
| | 2 | | 1 | 1 | 2 | | | 1 | | | 1 |
| | Totals | 59 | 37 | 8 | 104 | 7 | 52 | 3 | 34 | 3 | 5 |
| Assault | 0 | 48 | 13 | 7 | 68 | 9 | 39 | 4 | 9 | 2 | 5 |
| | 1 | 11 | 1 | 1 | 13 | 5 | 6 | | 1 | | 1 |
| | 2 | 3 | | 1 | 4 | 2 | 1 | | | 1 | |
| | 3 | | 1 | | 1 | | | 1 | | | |
| | Totals | 62 | 15 | 9 | 86 | 16 | 46 | 5 | 10 | 3 | 6 |

* This should be interpreted as 3 or more previous records.

TABLE XI

Percentages of parolees in the more common forms of crime who served the minimum (Group A), those who served less than the minimum (Group B), and those who served more than the minimum (Group C), together with averages pertaining to minimum sentences received and sentences served by each of the three groups. Averages computed from totals ranging between 20 and 40 cases are marked with an "*." Averages are omitted where the total number of cases is less than 20.

| Crime | Previous Records | Number of Cases | Distribution by Percentages | | | Average Time of Minimum Time in Years | | | Average Time Served Time in Years | | Average Decrease in Group B | Average Increase in Group C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Group A | Group B | Group C | Group A | Group B | Group C | Group B | Group C | | |
| | 0 | 376 | 79.0 | 17.6 | 3.4 | 1.21 | 2.95 | | 1.68 | | 1.27 | |
| Grand Larceny | 1* | 251 | 72.9 | 10.0 | 17.2 | 1.88 | 4.23* | 1.99 | 2.67* | 2.69 | 1.56* | .70 |
| | Total‡ | 627 | 76.6 | 14.5 | 8.9 | 1.47 | 3.30 | 1.79 | 1.95 | 2.46 | 1.35 | .67 |
| | 0 | 214 | 79.9 | 18.7 | 1.4 | 1.41 | 3.41 | | 2.12 | | 1.29 | |
| Burglary | 1† | 256 | 65.6 | 11.3 | 23.0 | 2.19 | 4.66* | 2.21 | 2.92* | 2.99 | 1.74* | .78 |
| | Total‡ | 470 | 72.1 | 14.7 | 13.2 | 1.80 | 3.93 | 2.15 | 2.46 | 2.92 | 1.01 | .77 |
| | 0 | 192 | 77.6 | 19.3 | 3.1 | 1.17 | 1.99* | | 1.23* | | .76* | |
| Forgery | 1† | 192 | 70.8 | 10.9 | 18.2 | 2.16 | 3.88* | 1.53* | 2.29* | 2.10* | 1.59* | .57* |
| | Total‡ | 384 | 74.2 | 15.1 | 10.7 | 1.64 | 2.68 | 1.49 | 1.61 | 2.06 | .62 | .57 |
| Illegal Sale of Liquor | 0 | 224 | 79.9 | 19.6 | 0.4 | 1.05 | 1.29 | | 0.81 | | .48 | |
| | 1† | 37 | 86.5 | 2.7 | 10.8 | 1.23* | | | | | | |
| | Total‡ | 261 | 80.8 | 17.2 | 1.9 | 1.12 | 1.30 | | 0.83 | | .47 | |
| | 0 | 157 | 26.8 | 71.3 | 1.9 | 4.90 | 6.19 | | 3.61 | | 2.58 | |
| Robbery | 1† | 77 | 48.1 | 45.4 | 6.5 | 5.10* | 7.79* | | 4.80* | | 2.99* | |
| | Total‡ | 234 | 33.8 | 62.8 | 3.4 | 5.00 | 6.27 | | 3.95 | | 2.62 | |
| Carnal Knowledge | 0 | 93 | 55.9 | 37.6 | 6.5 | 3.28 | 7.07* | | 3.71* | | 3.36* | |
| | Total‡ | 104 | 56.7 | 35.6 | 7.7 | 3.14 | 6.97* | | 3.65* | | 3.32* | |
| | 0 | 68 | 70.5 | 19.1 | 10.3 | 1.98 | | | | | | |
| Assault | Total‡ | 86 | 72.1 | 17.4 | 10.5 | 2.04 | | | | | | |

† One or more previous records.
‡ "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

adequate to warrant any final conclusions about time received and time served in each of the three groups, a few general facts are worth noting. In the first place, the data in Table XI reveal clearly that Group B, which is released before the expiration of the minimum, is in every case the one that has received the longest minimum and in several instances, the average time is twice as long in Group B as in Group A. The average time in Group C is but little longer than that for Group A.

In average time served the sentences in Group B are now more nearly like those of both Groups A and C. As shown in the last two

columns, the reductions in time for Group B were considerably greater than the increases in time for Group C with the effect that some of the divisions in Group C serve longer sentences than corresponding divisions in Group B. This represents a tendency on the part of the Parole Board to equalize the sentences served in the different groups because, in general, the larger reductions (in Group B) have occurred in those divisions which had received the larger minimum sentences in the first place.

Table XII presents, as far as the number of cases permit, an indication of the extent of violation in Groups A, B, and C in the various crimes. If one considers totals only, which also provide the larger frequencies, it is evident that Group B has a rate of violation which is noticeably less than that in Group A, and the percentage in Group C tends to be markedly higher than in Group A. This again tends to reveal, though only in a small way, that more violations occur in the longer sentences than in the shorter ones, although this is not so clearly revealed in this table as it was in Tables IX and X.

The combined data for Grand Larceny, Burglary, and Forgery[9] are presented in Table XIII, where the percentages of violation also show that the rate is clearly lower in Group B than it is in either Group A or Group C and the latter group has the largest percentage of violation. According to the totals, one-third of the Parolees in Group B are violators, whereas two-thirds in Group C are violators and the proportional number in Group A is only about nine per cent greater than in Group B.

The results for average duration of minimum and average sentence served are similar to those presented in Table XI. The results in Table XIII, however, reveal more definitely that the average sentence served in Group C is more nearly the same as that served in Group B in the divisions of one and no previous records. In two or more previous records Group B still has a longer sentence than Group C, just as it has the longest average minimum by a decisive margin. Thus, a comparison of Groups B and C with Group A in sentences served and in percentage of violation reveals again that the parolees with the longer sentences tend to violate more than those with the shorter sentences.

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[9] These three crimes, which include about 60 per cent of all parolees, were selected for composite presentation because of the relatively large number of cases in each, because of similarity in frequency of violation and also because of similar distributions when each is divided into Groups A, B, and C.

## TABLE XII

Percentage of violation by the inmates in the more common forms of crime—classified into Groups A, B, and C according to type of sentence served. Percentages marked with an "*" are based on totals between 20 and 40. Percentages are omitted where the number of cases is less than 20.

| Crime | Previous Records | Number of Cases | Percentage of Violation Group A | Group B | Group C |
|---|---|---|---|---|---|
| Grand Larceny | 0 | 376 | 31.3 | 27.3 | |
| | 1† | 251 | 44.8 | 36.0* | 58.4 |
| | Total‡ | 627 | 36.5 | 29.7 | 6.07 |
| Burglary | 0 | 214 | 44.4 | 32.5 | |
| | 1† | 256 | 62.7 | 44.8* | 69.5 |
| | Total‡ | 470 | 53.7 | 37.7 | 67.7 |
| Forgery | 0 | 192 | 38.3 | 29.7* | |
| | 1† | 192 | 52.2 | 47.6* | 85.7* |
| | Total‡ | 384 | 44.9 | 36.2 | 80.5 |

| Crime | Previous Records | Number of Cases | Percentage of Violation Group A | Group B | Group C |
|---|---|---|---|---|---|
| Illegal Sale of Liquor | 0 | 224 | 8.4 | 2.5 | |
| | 1† | 37 | 15.6* | | |
| | Total‡ | 261 | 9.5 | 2.2 | |
| Robbery | 0 | 157 | 54.8 | 33.0 | |
| | 1† | 77 | 51.4* | 54.3* | |
| | Total‡ | 234 | 53.2 | 38.1 | |
| Carnal Knowledge | 0 | 93 | 13.5 | 5.7* | |
| | Total‡ | 104 | 11.9 | 8.1* | |
| Assault | 0 | 68 | 18.8 | | |
| | Total‡ | 86 | 25.8 | | |

† One or more previous records.

‡ "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

## TABLE XIII

Percentage of violation, average minimum received, etc., by the inmates in three crimes considered together—Grand Larceny, Burglary, and Forgery—classified in Groups A, B, and C. Averages marked with an "*" are based on totals between 20 and 40. The percentage omitted involved less than 20 cases.

| Previous Records | Number of Cases | Percentage of Violation Group A | Group B | Group C | Average Time of Minimum Time in years Group A | Group B | Group C | Average Time Served Time in years Group A | Group B | Group C | Distribution by Percentages Group A | Group B | Group C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 782 | 36.6 | 29.4 | 59.1 | 1.26 | 2.82 | 1.14* | 1.26 | 1.69 | 1.70* | 78.9 | 18.3 | 2.8 |
| 1 | 474 | 51.0 | 36.7 | 60.7 | 1.93 | 3.53 | 1.67 | 1.93 | 2.37 | 2.27 | 74.5 | 12.6 | 12.9 |
| 2† | 225 | 53.2 | — | 77.6 | 2.43 | 7.01* | 2.21 | 2.43 | 4.19* | 2.99 | 59.5 | 6.7 | 33.8 |
| Total‡ | 1481 | 43.0 | 33.9 | 68.6 | 1.62 | 3.31 | 1.85 | 1.62 | 2.02 | 2.54 | 74.5 | 14.7 | 10.7 |

† Two or more previous records.

‡ "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

Table XIV, which deals with the same inmates as did Table XIII, presents data on violators and non-violators separately in an attempt to discover possible differences when they are classified into Groups A, B, and C. The distribution of violators in each of the three groups is not very much different from the distribution of non-violators, although there is a tendency for a greater proportion of violators than non-violators to be in Group C. The violators in both Group A and Group B

TABLE XIV

Percentages of violators and of non-violators in Grand Larceny, Burglary, and Forgery who may be classified in Groups A, B, and C, together with averages pertaining to minimum sentences received and sentences served by each of the three groups. Averages computed from totals ranging between 20 and 40 cases are marked with an "*." Averages are omitted where the total number of cases is less than 20.

| Previous Records | Status on Parole | Number of Cases | Distribution by Percentages | | | Average Time of Minimum Time in years | | | Average Time Served Time in years | | Average Decrease in Group B | Average Increase in Group C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Group A | Group B | Group C | Group A | Group B | Group C | Group B | Group C | | |
| 0 | Viol. | 281 | 80.4 | 14.9 | 4.6 | 1.35 | 3.00 | | 1.83 | | 1.17 | |
| | Non. | 501 | 78.0 | 20.2 | 1.8 | 1.20 | 2.75 | | 1.63 | | 1.12 | |
| 1 | Viol. | 239 | 75.3 | 9.2 | 15.5 | 2.00 | 4.00* | 1.56* | 2.44* | 2.14* | 1.56* | .58* |
| | Non. | 235 | 73.6 | 16.2 | 10.2 | 1.84 | 3.26* | 1.83* | 2.17* | 2.45* | 1.09* | .62* |
| 2† | Viol. | 148 | 53.4 | 6.7 | 39.9 | 2.52 | | 2.12 | | 2.90 | | .78 |
| | Non. | 77 | 71.4 | 6.5 | 22.1 | 2.30 | | | | | | |
| Total‡ | Viol. | 668 | 72.6 | 11.1 | 16.3 | 1.79 | 3.93 | 1.83 | 2.33 | 2.56 | 1.60 | .73 |
| | Non. | 813 | 76.1 | 17.7 | 6.2 | 1.47 | 2.99 | 1.91 | 1.86 | 2.56 | 1.13 | .64 |

† Two or more previous records.
‡ "Total" means here that all cases are considered in one group regardless of variation in number of previous records.

have received longer minimum sentences than have the non-violators; but in Group C. which represents only a limited number of cases, the non-violators receive the longer sentences. Although the reductions in sentences served in Group B are greater for the violator than for the non-violator, the former still serves the longer sentences in Groups A and B, the groups which represent the greater number of cases. The totals for Group C show that the average time served is the same for the violator as for the non-violator; this fact is significant, but since the number of cases represented is rather small the composite data still reveal that on the average there is a greater percentage of violation in the longer sentences than in the shorter ones.

It should not be assumed from the foregoing that a comparatively high rate of violation in the longer sentences is invariably due merely to the length of sentence. At least, such an assumption is unwarranted without the evaluation of the many factors which may affect the parolee both before and after his release. Furthermore, violations occur in all sentences, even the shortest. Perhaps too, it is the worst type of offender who is frequently recognized as such and is, therefore, given a relatively long sentence or who is recognized by the Parole Board and held beyond his minimum. It should be realized, however, that a sentence can probably be too long to insure satisfactory behavior on parole, just as a sentence can probably be too short to have the necessary deterrent effect. And it should also be recognized that the reduction of time to be served, especially in the case of the longer sentences received, may have a wholesome effect on at least some inmates concerned, whereas a detrimental effect may likewise occur when some are required to serve several months or years beyond the time designated by the minimum. The problem is a complicated one, but carefully controlled experimentation on the significance of length of sentence might well be carried out to provide more definite information as to the optimum sentence for different types of criminals.

In this study of sentences in relation to parole and its violation the main facts revealed by the data at hand are: (1) minimum sentences received and sentences served vary with the nature of the crime and with the number of previous commitments; (2) they vary considerably within a crime and also within its subdivisions; (3) in most criminal groups sentences served tend to be shorter than the minimum sentences received—the exceptions occur in groups with two or more previous records; (4) in most crimes the greater number of sentences received and sentences served are between one and two years; (5) in most criminal groups, over 70 per cent serve the time indicated by the minimum, from 15 per cent to 20 per cent less than the minimum, and commonly less than 10 per cent serve more than the minimum; (6) the greater reductions in length of sentences served occur in the longer minimum sentences; (7) violators have generally been required to serve a slightly longer sentence than non-violators; and (8) the percentage of violation is greater in the longer sentences than in the shorter ones.

# THE INHERITANCE OF REACTION TO PHYSIOLOGIC RACES OF *TILLETIA TRITICI* (BJERK.) WINT. IN A WINTER WHEAT CROSS[1]

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## INTRODUCTION

Bunt, caused by *Tilletia levis* Kühn and *T. tritici* (Bjerk.) Wint., continues to be the major hazard in wheat production in the Pacific Northwest. Seed treatment by the proper application of recommended fungicides is usually effective in controlling the disease in the spring-wheat producing areas. However, probably because of the use of improper methods of seed treatment, and in some cases complete omission of seed treatment, the disease is not effectively controlled. In the areas of the Pacific Northwest planted to winter wheat, seed treatment is less effective. Heald and George (1918), working on the wind dissemination of bunt spores, showed this lack of effective control to be due to the presence of the bunt organism in the soil at the time of planting in the fall. It is now almost universally accepted that the production of bunt-resistant varieties in combination with seed treatment is the most effective method to combat this disease.

The heritability of bunt resistance has been proved beyond all doubt and the exact mode of inheritance has been established in a number of wheat varieties. In order for the plant breeder to proceed most intelligently in the production of bunt-resistant varieties, it is necessary that he have available considerable information regarding the mode of inheritance of all important varieties to the important physiologic races of the bunt organism. This paper presents the results of an investigation on the inheritance of the individual reactions in a winter wheat cross to two physiologic races of *Tilletia tritici*, as well as the reaction to a composite mixture of these two races.

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[1] Scientific Paper No. 392, College of Agriculture and Experiment Station, State College of Washington, Pullman, Washington.

[2] Coöperative investigations between Washington Agricultural Experiment Station and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Dept. of Agriculture. This paper is a portion of a dissertation submitted to the faculty of the State College of Washington in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

## REVIEW OF LITERATURE

The mode of inheritance of reaction to physiologic races of *Tilletia tritici* and *T. levis* in wheat has been explained on one, two, three, and multiple factors. For convenience, the literature on the nature of segregation may be grouped under four heads:

(a) *Monohybrid ratios.* Gaines and Smith (1933) reported results in Hohenheimer x White Odessa to two races of *Tilletia tritici* (T-2 and T-11)[3] and one of *T. levis* (L-4)[3] A study of the reaction of 74 $F_3$ families indicated that Hohenheimer possesses one factor for resistance to T-2. This same factor also controlled the resistance to L-4, as was shown by a correlation coefficient of .93± .01 between the two portions of $F_3$ seed inoculated with the two races. Previous to 1933 Briggs (1926) and Churchward (1931 and 1932), working with single races, reported monohybrid ratios. Additional monohybrid ratios have been reported by Briggs (1933, 1934, and 1936), Smith (1933), Kilduff (1933), and Bressman and Harris (1933).

(b) *Dihybrid ratios.* Various modifications of a 15:1 ratio have been reported by Gaines and Singleton (1926), Briggs (1933 and 1934), Gaines and Smith (1933), Schlehuber (1935), Nieves (1936), and Crepin, Bustarret and Chevalier (1937). The work of Nieves seems the most complete. He analyzed the inheritance of reaction of 283 $F_3$ families of a cross between Barletta x Florence to a race of *Tilletia tritici.* He obtained a ratio of

9 hypersusceptible (like Barletta)
3 susceptible
3 intermediate susceptible
1 resistant (like Florence)

On the basis of the 283 $F_3$ families the ratios were 152:58:49:23 when 158.6:52.9:52.9:17.6 were expected. The $F_1$ was as susceptible as the susceptible parent, dominance of susceptibility in this cross thus being demonstrated.

Although the 9:3:3:1 ratio is the more usual one reported, the author (1935) reported a 7:4:4:1 ratio in a cross between Albit x Minhardi to a race of *Tilletia tritici.* This race produced 64 per cent bunt on Minhardi and none on Albit. The $F_3$ segregated into

7 smut-free (like Albit)

[3]Old race numbers of *Tilletia tritici* and *T. levis,* respectively, of Washington Agricultural Experiment Station; recently these have been renumbered by Rodenhisher and Holton (1937).

4 intermediate resistant
4 intermediate susceptible
1 susceptible (like Minhardi)

(c) *Trihybrid ratios.* Smith (1933) studied the inheritance of Hope x Jenkin to T-3, L-5, and a mixture of T-1, T-2, and L-4. He explained his results on the basis of three main factors for resistance, with no indication of either dominance or susceptibility. He also suggested that the resistance in Hope to any one of the five physiologic races is controlled by the same three factors. Modified 63:1 ratios have also been reported by Briggs (1933) and Schlehuber (1935).

(d) *Number of factors not determined.* The inheritance of reaction in two crosses, Turkey x Hybrid 128 and Turkey x Florence, was studied by Gaines (1920). He obtained a continuous series ranging from complete immunity to complete susceptibility in the $F_2$ and $F_3$. From these data he concluded that resistance, if Mendelian, is composed of multiple factors, but he did not state the exact number. He further suggested that most of the factors for resistance are recessive, and Turkey and Florence each have different and distant factors. Data from which it was impossible to determine the exact number of factors responsible for resistance were also obtained by Gieseke (1929), Knorr (1929), Aamodt (1931), Smith (1933), Clark, Quisenberry and Powers (1933), Wismer (1934), Ausemus (1934), Schlehuber (1935), and Vogel and Holton (1938).

## MATERIALS AND METHODS

The materials in the present study consisted of two varieties of winter wheat—White Odessa, C. I.[4] 4655, and Turkey-Florence, C. I. 10080—and two physiologic races of *Tilletia tritici*—Flor's (1933), Ft-4, and another race of *T. tritici*, the latter having been first isolated on the variety *Ridit.*[5]

A part of the $F_1$ seed, one $F_2$ population, and one series in $F_3$ were treated with copper carbonate to furnish material for each succeeding generation. The seed of each $F_2$ plant was divided into four portions of 75 seeds each. A total of 108 $F_3$ families and 12 rod rows each of the two parents were tested for their reaction to Ft-4; 91 $F_3$ families

[4] C. I. denotes accession number of the Division of Cereal Crops and Diseases (formerly Office of Cereal Investigations) of U. S. Department of Agriculture.

[5] For the sake of brevity, this race will hereafter be referred to as Ridit *tritici.*

and 11 rod rows of each of the parents to Ridit *trititci.* In addition, 77 $F_3$ families and nine rod rows each of the parents were tested for their reaction to an equal mixture of the two races. All the $F_3$ families and the two parents were tested in 1934; in 1935 a few $F_1$ plants, an $F_2$ population, a few selected $F_3$ and $F_4$ families, and the two parents were tested.

The seed was inoculated by placing the various portions of 75 seeds in a glass vial together with a sufficient quantity of fresh viable bunt spores, which had been tested for their germination just prior to inoculation. The vial was shaken vigorously until all seeds were thoroughly blackened with spores.

The 1934 planting plan may be summarized as follows:

| Treatment | Number of rod rows of 75 seeds each | |
|---|---|---|
| | Parents | White Odessa x Turkey-Florence $F_3$ |
| Copper carbonate | 13 | 117 |
| Ft-4 | 12 | 108 |
| Ridit *tritici* | 11 | 91 |
| Mixture of the two races | 9 | 77 |

Shortly before maturity (stiff-dough stage) all plants were pulled and classified into five bunt groups: 0, 20, 50, 80, and 100 per cent.

The percentage of smut in a row was calculated as suggested and used by Smith (1933) and also used by the author (1935); to illustrate, row 145 of White Odessa had six smut-free plants, one 20 per cent smutted plant, five 50 per cent smutted plants, four 80 per cent smutted plants, and forty-nine 100 per cent smutted plants.

$$\frac{(1 \times 20) + (5 \times 50) + (4 \times 80) + (49 \times 100)}{65 \text{ (total number of plants)}} = 84 \text{ per cent bunt}$$

## RESULTS AND DISCUSSION

*Reaction to Ft-4.*—The reactions of White Odessa, Turkey-Florence, $F_1$, $F_2$, $F_3$, and selected $F_3$ and their $F_4$ progeny to Ft-4 are shown in Table 1. The parent and $F_3$ distribution placed on a percentage basis is shown graphically in Fig. 1. The average percentage of bunt in 12 rows of White Odessa was 93.5 ± 2.39, the range being from

Table 1. Reaction of White Odessa Wash. 2308, Turkey-Florence Wash. 2471, $F_1$, $F_2$, and Selected $F_3$ and Their $F_4$ Progeny to Ft-4. The Percentage of Smut Is Divided into 15 Classes, Each Increasing by an Arithmetical Progression of 1%

| Cross or parent | | Year | Smut classes | | | | | | | | | | | | | | | Total | Average % bunt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| | | | 0 | tr.-1 | 1.1-3 | 3.1-6 | 6.1-10 | 11-15 | 16-21 | 22-28 | 29-36 | 37-45 | 46-55 | 56-66 | 67-78 | 79-91 | 92-100 | | |
| | | | | | | | | (Number of rows) | | | | | | | | | | | |
| White Odessa | | 1934 | | | | | | | | | | | | | | 1 | 11 | 12 | 93.5 ± 2.39 |
| Turkey-Florence | | 1934 | 1 | 6 | 5 | | | | | | | | | | | | | 12 | 0.85 ± 0.479 |
| $F_3$ | | 1934 | | | 3 | 7 | 7 | 10 | 6 | 7 | 12 | 10 | 11 | 14 | 15 | 6 | | 108 | 40.3 ± 17.2 |
| White Odessa | | 1935 | | | | | | | | | | | | 1 | 4 | 11 | | 16 | 80.0 ± 5.06 |
| Turkey-Florence | | 1935 | 4 | 12 | | | | | | | | | | | | | | 16 | .40 ± 0.216 |
| $F_1$ | | 1935 | | | | | 1 | (av. of 5 plants) | | | | | | | | | | 1 | 8.0 |
| $F_2$ | | 1935 | | | | | | | 1 | (av. of 104 plants) | | | | | | | | 1 | 19.0 |
| Family 7 | $F_3$ row | 1934 | | | 1 | | | | | | | | | | | | | 1 | 2.5 |
| | $F_4$ rows | 1935 | | 17 | 20 | 5 | 5 | 2 | | | | | | | | | | 49 | 2.9 ± 2.06 |
| Family 14 | $F_3$ row | 1934 | | | 1 | | | | | | | | | | | | | 1 | 2.4 |
| | $F_3$ row | 1935 | | | | | 1 | | | | | | | | | | | 1 | 7.0 |
| | $F_4$ rows | 1935 | | 3 | 15 | 13 | 8 | | | | | | | | | | | 39 | 4.0 ± 1.50 |
| Family 60 | $F_3$ row | 1934 | | | 1 | | | | | | | | | | | | | 1 | 3.0 |
| | $F_3$ row | 1935 | | | 1 | | | | | | | | | | | | | 1 | 2.0 |
| | $F_4$ rows | 1935 | | 8 | 32 | 7 | | | | | | | | | | | | 47 | 2.0 ± 0.78 |
| Family 19 | $F_3$ row | 1934 | | | | | | 1 | | | | | | | | | | 1 | 11.0 |
| | $F_3$ row | 1935 | | | | | 1 | | | | | | | | | | | 1 | 8.8 |
| | $F_4$ rows | 1935 | | | | 5 | 10 | 7 | 6 | 7 | | 1 | 2 | | | | | 38 | 17.0 ± 8.11 |
| Family 20 | $F_3$ row | 1934 | | | | | | | | | 1 | | | | | | | 1 | 36.0 |
| | $F_3$ row | 1935 | | | | | 1 | | | | | | | | | | | 1 | 6.5 |
| | $F_4$ rows | 1935 | | | 1 | 6 | 9 | 4 | 10 | 10 | 3 | 2 | 1 | 1 | | | | 47 | 19.0 ± 8.32 |
| Family 21 | $F_3$ row | 1934 | | | | | | | | | | | | | | 1 | | 1 | 80.0 |
| | $F_3$ row | 1935 | | | | | | | | | | | 1 | | | | | 1 | 54.0 |
| | $F_4$ rows | 1935 | | | | | | | | | | 1 | 3 | 6 | 14 | 12 | | 36 | 72.0 ± 7.67 |
| Family 4 | $F_3$ row | 1934 | | | | | | | | | | | | | | 1 | | 1 | 87.0 |
| | $F_3$ row | 1935 | | | | | | | | | | | | 1 | | | | 1 | 57.0 |
| | $F_4$ rows | 1935 | | | | | | | | 2 | | 3 | 3 | 8 | 6 | 2 | | 24 | 59.0 ± 10.89 |

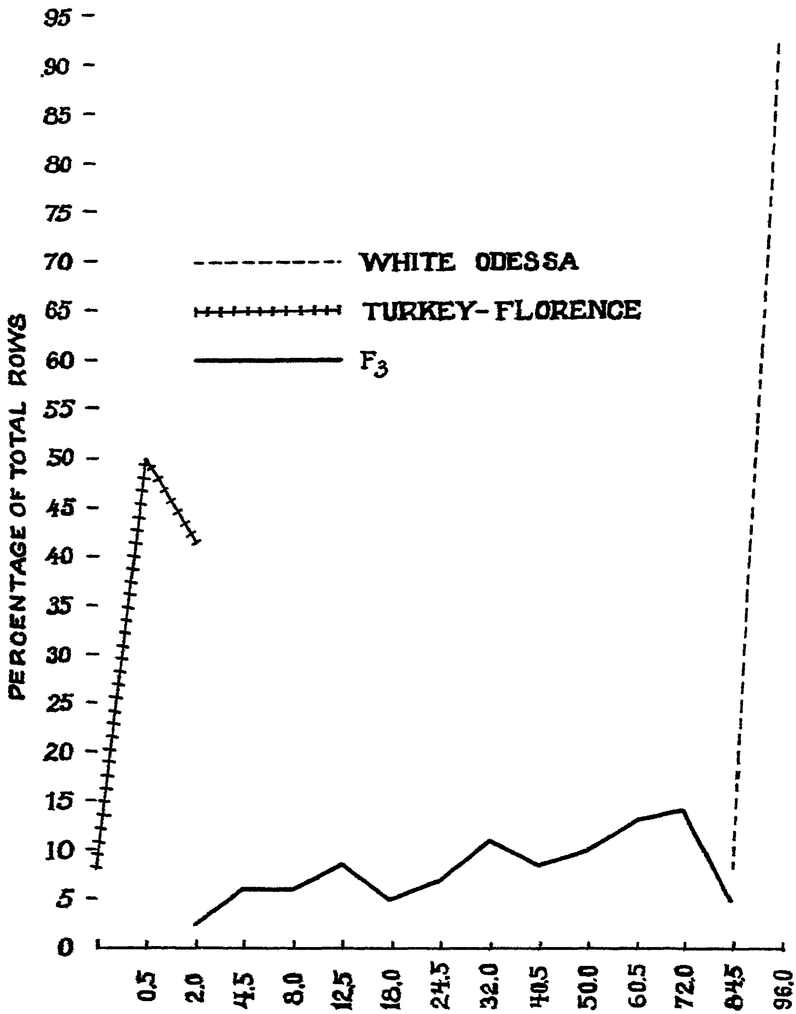


FIG. 1 DISTRIBUTION OF PARENTS AND $F_3$ FAMILIES ACCORDING TO THE PERCENTAGE OF BUNT. INOCULUM FT.-4

84 to 98 per cent. It should be pointed out, however, that the row which produced 84 per cent was a border row, and it is questionable whether or not it should be used in the analysis. This was the only row of the whole experiment in which the deviation from the mean does not come within the limit of three times the probable error. This consideration will arise again when the segregations of the various $F_3$ families are discussed. Twelve rows of Turkey-Florence averaged 0.85 $\pm$ 0.479 per cent bunt, with a range of 0.0 to 2.3 per cent. The row with 2.3 per cent deviates 1.45 from the mean; three times the probable error of the mean (0.479) is 1.44; hence the 1.45 deviation from the mean is not considered a serious one. The average percentage of bunt of the 108 $F_3$ families is 40.3 $\pm$ 17.2. None of the progeny reach the extremes in percentage of bunt of the two parents. The distribution of the $F_3$ families within the various bunt classes suggests a rather complex mode of inheritance which cannot be explained on a mono- or dihybrid basis of inheritance.

A frequency curve seems to serve the purpose of segregating the various genotypic classes clearly enough if the mode of inheritance is a simple 3:1 or even a 15:1, but if the segregation is more complex some other method of finding the limits between the various genotypes must be used.

It is not unusual to find the coefficient of variability (C.V.) used as a measure of heterozygosity, and in some types of segregations it seems to be well adapted for this use. Because the C. V. is primarily a function of the mean (M), however, it was not felt it could be used in this work, inasmuch as the means are so widely different (from 0 to 98 per cent); consequently, the standard deviation (S. D.) was employed. The standard deviation of every parent and progeny has been calculated according to the following formula:

$$\text{S. D.} = \frac{\sqrt{\Sigma(V^2 \,.\, f)} - M^2}{n}$$

in which V = the bunt class (0, 20, 50, 80, and 100 per cent); f(frequency = the number of plants in the bunt class; n = the total number of plants in the row; and M = the average percentage of bunt in the row. For example, row 157 of White Odessa had the following distribution of the smutted plants:

| V | f | $\Sigma(fV)$ | $\Sigma(V^2 \cdot f)$ |
|---|---|---|---|
| 0 | 2 | 0 | 0 |
| 20 | 2 | 40 | 800 |
| 50 | 1 | 50 | 2,500 |
| 80 | 5 | 400 | 32,000 |
| 100 | 58 | 5,800 | 580,000 |
| | 68 | 6,290 | 615,300 |

$$M = \frac{6,290}{68} = 93$$

$$\text{S. D.} = \sqrt{\frac{615,300}{68} - 8,649} = \sqrt{9,049 - 8,649} = \sqrt{400} = 20$$

The distribution of the two parents and the 108 $F_3$ families in bunt classes is plotted against their standard deviations within rows in Fig. 2. The standard deviations of Turkey-Florence range from 0 to 12.1; those of White Odessa from 9.5 to 21.3 if the border row, which produced only 84 per cent smut, is eliminated, or from 9.5 to 32.8 with this

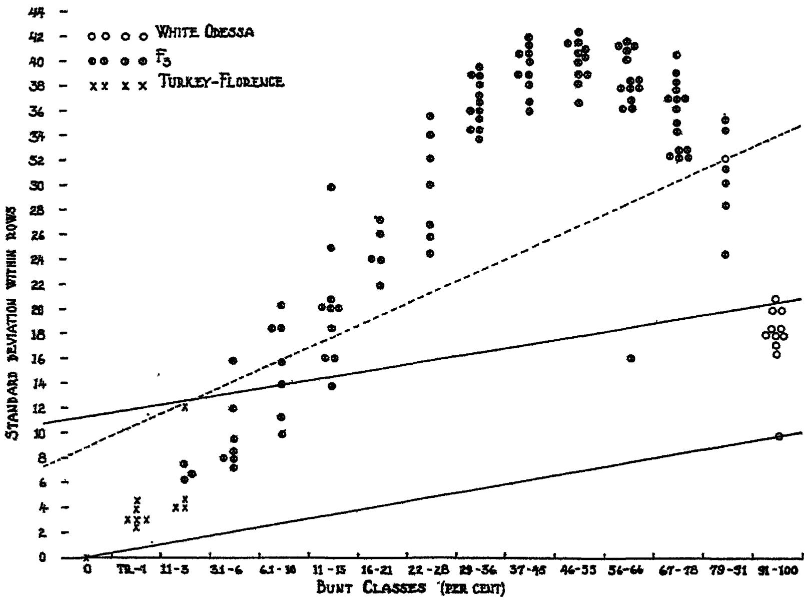


FIG. 2 RELATION BETWEEN BUNT CLASSES AND THE STANDARD DEVIATION WITHIN ROWS OF PARENTS AND $F_3$ FAMILIES. INOCULUM TR.-4

row. As already pointed out, this row had a deviation from the mean of 3.97 times the probable error. Three times the probable error gives odds of 22:1, which is interpreted that the odds are 22:1 against a deviation being found as great as or greater than three times the probable error due to errors of sampling or chance alone. Interpreted another way, it would be expected that once out of 23 times a deviation as great as three times the probable error would occur because of random variation, or because of chance. Odds between 95 and 142:1 are expected when the deviation from the mean is 3.97 times the probable error, so that causes other than those arising from random sampling must be sought. The fact that this was a border row offers nothing as an explanation, because it is not known whether border rows would show larger fluctuations. The chief fluctuation of this row as compared with the other check rows of White Odessa was in the number of smut-free plants, the numbers in the 20, 50, and 80 per cent smut groups being about the same as those in the other rows. The largest number of smut-free plants in the other White Odessa rows was two; in this row there were six. It is possible that a plant with more moisture and plant nutrients to draw from might outgrow the bunt mycelium. At this time no other explanation suggests itself.

In Fig. 2 the upper limits of the standard deviation of the two parents have been connected with each other and the lower limits with each other by two straight lines. The dotted line connects the standard deviation of the White Odessa row which had only 84 per cent bunt to the upper standard deviation of Turkey-Florence. It can be seen that this standard deviation is considerably higher than those of any of the other White Odessa rows. The two solid lines made by connecting the upper limits of the standard deviation of the two parents and those of the lower limits are exactly parallel. This fact suggests that the increase by an arithmetical progression of one per cent in size of the bunt classes going from the resistant to the susceptible parent is a logical procedure.

At first inspection of Fig. 2 it may seem that there are three $F_3$ families similar to Turkey-Florence, for the percentage of smut as well as its standard deviation comes within the range. Table 1 shows that three of the 108 $F_3$ families fall within the 1.1-3 per cent smut class, which is also the upper class of five of the 12 Turkey-Florence rows. The highest percentage of smut in any Turkey-Florence row is 2.3, whereas the three $F_3$ rows had averages of 2.4, 2.5, and 3.0, respectively.

In order to explain satisfactorily the genetics of this cross, it is obviously of prime importance to know whether or not these three rows possess similar genes for resistance as those found in Turkey-Florence. By a mere inspection of the $F_3$ frequency distribution in Table 1 and Figs. 1 and 2, it might be concluded that these three $F_3$ families are of the same genetic constitution as Turkey-Florence. Whether or not such is actually the case can be satisfactorily answered only by a test of the $F_4$ material of such questionable rows. This was considered when making the 1934 planting plan and for this reason a complete copper-carbonated series of all $F_3$ families was grown; this series further served the purpose of checking the soil infestation. No row in the copper-carbonated series had more than a trace of bunt.

The distribution of the $F_4$ of these three families into bunt classes is given in Table 1, where they appear as family Nos. 7, 14, and 60 with 2.5, 2.4, and 3.0 per cent bunt, respectively, in the $F_3$. Because this test was made in 1935, the bunt percentages of these $F_4$ families must be compared with those of the parents made in the same year. Sixteen rows of Turkey-Florence produced an average of $0.40 \pm 0.22$ per cent bunt, and no row had more than one per cent, a spread through the first two bunt classes only.

Family 7, which produced an average of 2.5 per cent bunt in the $F_3$ in 1934, produced an average of $2.9 \pm 2.06$ per cent bunt in 49 $F_4$ rows. No row was in the 0 per cent bunt class; in Turkey-Florence four rows, or 25 per cent, were in this class. Furthermore, the spread of the $F_4$ through five bunt classes compared to two and three for Turkey-Florence and White Odessa, respectively, would suggest that the $F_2$ plant from which these rows originated was not homozygous for the genes governing resistance to Ft-4.

Family 14 produced 2.4 per cent bunt in the $F_3$ in 1934 and 7.0 per cent in 1935. Thirty-nine $F_4$ rows produced an average of $4.0 \pm 1.50$ per cent bunt in 1935, and here again not one row in the total of 39 rows was entirely smut free. These 39 rows spread through only four bunt classes with only three rows in the second class, so that this family appears to be rather homozygous, but not like Turkey-Florence.

The third $F_3$ family of questionable constitution is number 60, which produced an average of 3.0 per cent bunt in 1934 and 2.0 in 1935. The 47 $F_4$ rows produced an average of $2.0 \pm 0.78$ per cent bunt in 1935. Here again, no row which remained entirely smut free was found, so that this family, too, is different from Turkey-Florence. However,

the $F_2$ plant from which these $F_3$ and $F_4$ were selected may have been homozygous, since 32 of the 47 $F_4$ rows are in the third class, and the remaining 15 rows in classes two and four, the range being only three classes.

As is further indicated by Table 1, the type of segregation of the $F_4$ rows of families 7, 14, and 60 shows that they are distinctly different from Turkey-Florence and strongly suggests that they are genetically different from each other. Family 60 is homozygous for genes governing resistance to Ft-4 but lacks one factor carried by Turkey-Florence. It has been shown, then, that on the resistant end of the curve not once in 108 $F_3$ families was the resistance of Turkey-Florence recovered.

The susceptible end of the curve should now be considered. As stated before, White Odessa produced an average of $93.5 \pm 2.39$ per cent bunt in 12 rows in 1934. All but one of the 12 rows are in the 15th bunt class (92-100). Six of the 108 $F_3$ families are in the 14th bunt class (79-91), but none in the 15th. In Fig. 3 it can be observed that, if the dotted line is taken as the upper limit of White Odessa, there are four $F_3$ families which have a standard deviation and a percentage of smut like White Odessa. The reasons for eliminating this row have already been given. If, then, the two lower lines in Fig. 2 are regarded as the limits of percentage of bunt and the S. D. of the two parents, it can be seen that no $F_3$ family has a combination of as high a percentage of smut with as low a standard deviation as has White Odessa.

The two $F_3$ families with the highest percentage of bunt (80 and 87) were tested in the $F_4$. $F_3$ family 21 with 80 per cent bunt in 1934 produced an average of $72.0 \pm 7.67$ per cent bunt in 36 $F_4$ rows in 1935 as compared to $80.0 \pm 5.06$ per cent in 16 rows of White Odessa in the same year. Though the percentages, 72 and 80, are not much different, the distribution of the 16 White Odessa rows compared to the 36 $F_4$ rows is different. The 36 $F_4$ rows spread through bunt classes 10-14, and the 16 White Odessa rows through only 12-14; whereas 10 of the $F_4$ families fall into classes 10, 11, and 12, only one White Odessa row falls into class 12. From this it must be concluded that family 21 is not of the same genetic constitution as White Odessa in regard to the genes controlling the resistance to Ft-4.

One other family, No. 4, which produced 87 per cent bunt in 1934 as an $F_3$, produced an average of only $59.0 \pm 10.89$ per cent bunt in 24 $F_4$ rows in 1935. Here both the percentage of bunt and the distribution differentiate it clearly from White Odessa.

Summarizing then, one may state that the three $F_3$ families on the resistant end of the curve as well as the two on the susceptible end were tested in the $F_4$. In no instance was the resistance of Turkey-Florence nor the susceptibility of White Odessa recovered. From this it was concluded that the resistance of Turkey-Florence to Ft-4 is controlled by at least four factors. Because of this complex mode of inheritance, a complete genic analysis of the 108 $F_3$ families cannot be made.

In crosses of an immune parent (that is, one not producing bunt spores) with a susceptible one, the $F_1$ generally reacts like the resistant parent. If, however, a resistant parent which produces a trace of bunt is crossed with a susceptible one, dominance of susceptibility has generally been found. Table 2 has been included to give an indication of the reaction of the $F_1$ and $F_2$. Naturally, only very few $F_1$ plants can be available for such a test; however, they have been included here and

Table 2. Reaction of Parents, $F_1$, and $F_2$ to Physiologic Race Ft-4

| Number of plants in class | | | | | Total number of plants | Percentage of smut |
|---|---|---|---|---|---|---|
| 0 | 20 | 50 | 80 | 100 | | |
| | White Odessa | | | | | |
| 183 | 29 | 52 | 220 | 963 | 1,447 | 81.0 (Class 14) |
| | Turkey-Florence | | | | | |
| 1,496 | 24 | 1 | 0 | 1 | 1,522 | 0.41 (Class 2) |
| | | $F_1$ | | | | |
| 3 | 2 | 0 | 0 | 0 | 5 | 8.0 (Class 5) |
| | | $F_2$ | | | | |
| 74 | 9 | 3 | 9 | 9 | 104 | 19.0 (Class 7) |

they show a reaction intermediate between the two parents. According to the $F_2$ data, it would seem that the intermediate reaction is more toward the resistant parent. The $F_3$ data, however, do not bear this out.

It can be stated, then, in the cross White Odessa x Turkey-Florence the resistance to Ft-4 is controlled by at least four factors, cumulative

in effect, and that there is no distinct tendency toward dominance of resistance or susceptibility.

*Reaction to Ridit tritici.*—The reactions of White Odessa, Turkey-Florence, the $F_1$, $F_2$, $F_3$ and selected $F_3$ and their $F_4$ progeny to Ridit *tritici* is shown in Table 3. The parent and $F_3$ distribution placed on a percentage basis is shown graphically in Fig. 3. Eleven rod rows of

Table 3. Reaction of White Odessa, Turkey-Florence, $F_1$, $F_2$, $F_3$ and Selected $F_3$ and Their $F_4$ Progeny to Ridit *tritici*. The Percentage of Smut Is Divided into 15 Classes, Each Increasing by an Arithmetical Progression of 1%

| Cross or parent | | Year | Smut classes | | | | | | | | Total | Average per cent bunt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| | | | 22-28 | 29-36 | 37-45 | 46-55 | 56-66 | 67-78 | 79-91 | 92-100 | | |
| White Odessa | | 1934 | | | | 7 | 3 | 1 | | | 11 | 56.0 ± 4.22 |
| Turkey-Florence | | 1934 | | | | | 1 | 7 | 3 | | 11 | 76.0 ± 4.18 |
| $F_3$ | | 1934 | | 2 | 8 | 23 | 30 | 7 | 8 | 13 | 91 | 64.0 ± 12.00 |
| White Odessa | | 1935 | | 1 | | 1 | 4 | | | | 6 | 54.5 ± 7.44 |
| Turkey-Florence | | 1935 | | | 1 | 2 | 2 | 1 | | | 6 | 57.5 ± 6.41 |
| $F_1$ | | 1935 | | 1 (av. of 7 plants) | | | | | | | | 33.0 |
| $F_2$ | | 1935 | 1 (av. of 98 plants) | | | | | | | | | 24.0 |
| Family 43 | $F_3$ row | 1934 | | 1 | | | | | | | 1 | 30.0 |
| | $F_3$ row | 1935 | | | 1 | | | | | | 1 | 40.00 |
| | $F_4$ rows | 1935 | | 8 | 19 | 11 | 5 | | | | 43 | 45.0 ± 5.46 |
| Family 106 | $F_3$ row | 1934 | | | | | | | | 1 | 1 | 98.0 |
| | $F_3$ row | 1935 | | | | | | 1 | | | 1 | 77.0 |
| | $F_4$ rows | 1935 | | | | | | 2 | 28 | 16 | 46 | 89.0 ± 4.12 |

White Odessa produced an average of 56.0 ± 4.22 per cent bunt with a range from 49-72 per cent in 1934. These 11 rows are distributed in the bunt classes 11, 12, and 13. Turkey-Florence produced an average of 76.0 ± 4.18 per cent bunt in 11 rod rows in the same year, which range from 62-85 per cent. The 11 rod rows of Turkey-Florence are distributed in the bunt classes 12, 13, and 14. The distribution of the 91 $F_3$ families into bunt classes from 9-15 suggests transgressive segregation in resistance and in susceptibility to Ridit *tritici*. The fact that the number of families showing transgressive inheritance is rather large on both ends of the curve suggests that the resistance is controlled by relatively few factors.

There are 13 $F_3$ families which are clearly more susceptible than Turkey-Florence and a part of the eight in class 14 were considered

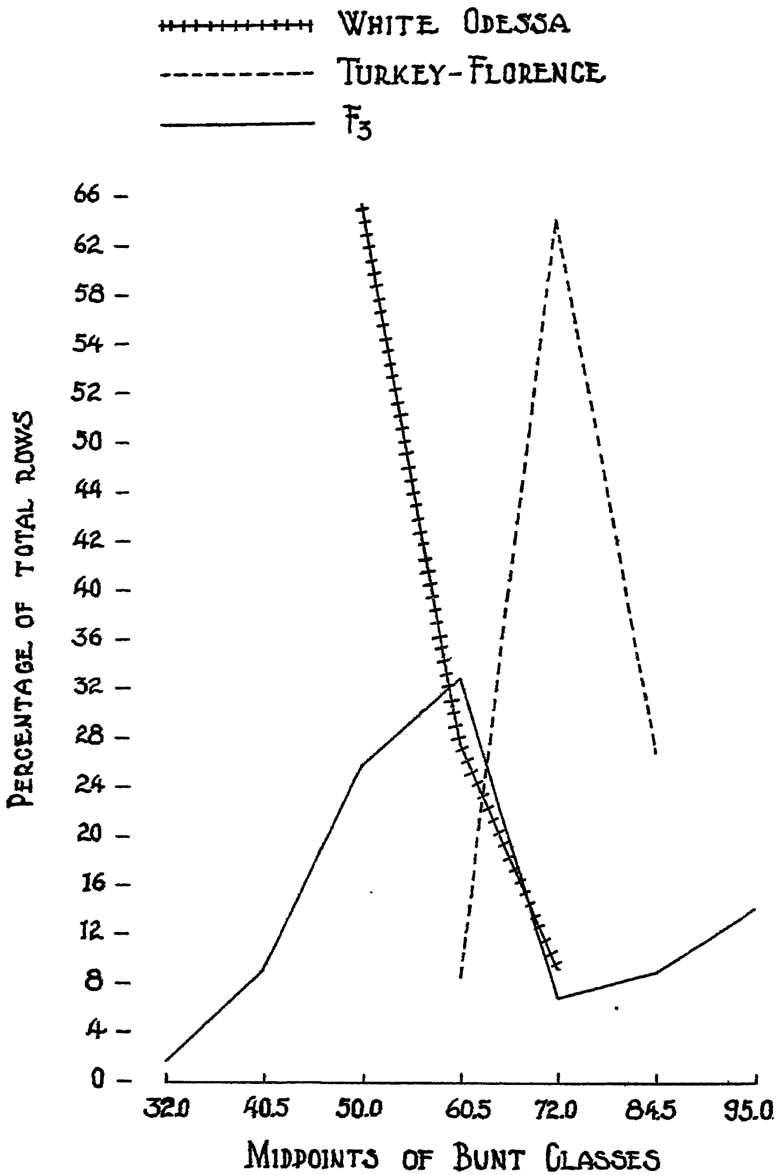


FIG. 3 DISTRIBUTION OF PARENTS AND $F_3$ FAMILIES ACCORDING TO THE PERCENTAGE OF BUNT. INOCULUM RIDIT <u>TRICITI</u>

along with this group, the remaining with those segregating like Turkey-Florence. Because three of the 11 Turkey-Florence rows, or 27.3 per cent, are in class 14, the same percentage of the eight hybrid rows were considered with the group segregating like Turkey-Florence; the remaining six of these eight rows, or 72.7 per cent, were grouped with those families more susceptible than Turkey-Florence. In short, a total of 19 $F_3$ families, calculated on the basis of the frequency curve, are more susceptible than Turkey-Florence; actually 21 of the 91 $F_3$ families, or 23.1 per cent, have more than 85 per cent smut, the upper limit of the more susceptible parent.

On the resistant end of the curve, 10 $F_3$ families are clearly more resistant than the more resistant parent, White Odessa. Because a part of the 23 $F_3$ families in bunt class 11 did not reach the lower limit of infection of White Odessa, they should be considered in the transgressive resistant types. Here, treating it similarly as was done on the other end of the curve, 7 of the 11 rows of White Odessa, or 63.6 per cent, fall into bunt class 11. Hence 36.4 per cent, or eight of the 23 rows, must be grouped with those $F_3$ families which were more resistant than White Odessa, the total being 18. By actual count, 16 of the 91 $F_3$ families, or 17.58 per cent, have less than 49 per cent smut, the lower limit of White Odessa.

The hypothesis proposed to explain the mode of inheritance of resistance in White Odessa x Turkey-Florence to Ridit *tritici* assumes a 2-factor difference, one of which, B, influences susceptibilty in the dominant condition, the other, a, in the recessive condition. It is assumed that White Odessa is of the constitution AABB, which causes its plants to fluctuate around a mean of 56 per cent bunt, and Turkey-Forence, aabb, which causes its plants to fluctuate around a mean of 76 per cent bunt.

The mean percentage of bunt around which those $F_3$ families showing transgressive segregation will fluctuate was established in order to account for the nine genotypes. The upper limit of the $F_3$ families is 98 per cent bunt; that of Turkey-Florence is 85, a difference of 13. It was assumed that the transgressive susceptible types will fluctuate around a mean of $[85 + (\frac{1}{2} \times 13)] = 92$. The lower limit of the $F_3$ families is 30 per cent bunt and that of White Odessa is 49, a difference of 19, and here it was assumed that the transgressive resistant types will fluctuate around a mean of $[49 - (\frac{1}{2} \times 19)] = 39$. Herewith the mean of the four homozygous types, AABB, aabb, aaBB, and

AAbb, have been established at 56, 76, 92, and 39 per cent. It is now necessary to establish the means of the heterozygous types.

The assumed genetic constitution of the White Odessa x Turkey-Florence $F_2$ plants which are heterozygous for either one or two factors is given in Table 4. The segregation in the $F_3$ families and the expected percentage of bunt of each $F_3$ genotype and of each $F_3$ row are also given in Table 4. With this information it is now possible to assign a definite figure to each of the nine genotypes around which the percentage of bunt is expected to fluctuate. The breeding behavior of each of the nine genotypes in the cross White Odessa x Turkey-Florence to Ridit *tritici* is given in Table 5.

Table 4. The Genetic Constitution of White Odessa X Turkey-Florence $F_2$ Plants Heterozygous for One and for Two Factors and the Segregation in $F_3$ with the Expected Percentage of Bunt from Ridit *tritici*

| $F_2$ heterozygotes | $F_3$ segregation | Percentage of bunt of $F_3$ genotypes | Av. percentage of bunt in $F_3$ row |
|---|---|---|---|
| AABb | 1AABB<br>2AABb<br>1AAbb | 56 x 1<br>56 x 2<br>39 x 1 | $\frac{207}{4} = 52$ |
| AaBB | 1AABB<br>2AaBB<br>1aaBB | 56 x 1<br>56 x 2<br>92 x 1 | $\frac{260}{4} = 65$ |
| Aabb | 1AAbb<br>2Aabb<br>1aabb | 39 x 1<br>39 x 2<br>76 x 1 | $\frac{193}{4} = 48$ |
| aaBb | 1aaBB<br>2aaBb<br>1aabb | 92 x 1<br>92 x 2<br>76 x 1 | $\frac{352}{4} = 88$ |
| AaBb | 1AABB<br>2AABb<br>1AAbb<br>2AaBB<br>4AaBb<br>2Aabb<br>1aaBB<br>2aaBb<br>1aabb | 56 x 1<br>56 x 2<br>39 x 1<br>56 x 2<br>56 x 4<br>39 x 2<br>92 x 1<br>92 x 2<br>76 x 1 | $\frac{973}{16} = 61$ |

It has already been pointed out that 16 rows of the 91 $F_3$ families, or 17.58 per cent, were more resistant than White Odessa. By reference to Table 5, it can be seen that genotypes AAbb and Aabb, or 18.75 per cent of the total of all nine genotypes, were expected to be more

Table 5. The Breeding Behavior of Each of the Nine Genotypes in the Cross White Odessa X Turkey-Florence When Inoculated with Ridit *tritici*

| Genotype | Breeding behavior of $F_2$ family | Expected mean percentage of bunt in F row |
|---|---|---|
| 1AABB | Breed true, like White Odessa | 56 |
| 2AABb | Segregate 3 like White Odessa: 1 more resistant | 52 |
| 1AAbb | Breed true, more resistant than White Odessa | 39 |
| 2AaBB | Segregate 3 like White Odessa: 1 more susceptible than Turkey-Florence | 65 |
| 4AaBb | Segregate: 9 like White Odessa; 3 more resistant than White Odessa; 3 more susceptible than Turkey-Florence; 1 like Turkey-Florence | 61 |
| 2Aabb | Segregate 3 more resistant than White Odessa: 1 like Turkey-Florence | 48 |
| 1aaBB | Breed true, more susceptible than Turkey-Flor. | 92 |
| 2aaBb | Segregate 3 more susceptible than Turkey-Flor.: 1 like Turkey-Florence | 88 |
| 1aabb | Breed true, like Turkey-Florence | 76 |

resistant than White Odessa, and this expectation is in close agreement with the actual. Twenty-one rows of the 91 $F_3$ families, or 23.1 per cent, were more susceptible than Turkey-Florence. Here again 18.75 per cent, genotypes aaBB and aaBb of Table 5, were expected.

The Chi-square ($X^2$) method as employed by Fisher (1936) was used to test the goodness of fit, which is as follows:

| | Observed | Calculated (18.75%) | O-C | $(O-C)^2$ | $\frac{(O-C)^2}{C}$ |
|---|---|---|---|---|---|
| Transgressive resistant types | 16 | 17.06 | 1.06 | 1.1236 | 0.066 |
| Transgressive susceptible types | 21 | 17.06 | 3.94 | 15.5236 | 0.910 |

$X^2 = 0.976$
P = .50-.30

The P value of .50-.30 shows that the observed values are close enough to the theoretical to be considered a good fit.

The data in Table 5 show that the genotype AaBb would be expected to produce 61 per cent bunt (see Table 4 for calculation of this percentage). Therefore the largest number of $F_3$ families should be expected in the bunt class with this percentage of bunt. Thirty rows of the 91 $F_3$ families, or 33.2 per cent, fall into bunt class 12 (see Table 3), which contains the $F_3$ families with 61 per cent bunt; also, 61 per cent is exactly the midpoint of this class.

The final proof of the suggested hypothesis is a comparison of the calculated mean percentage of bunt in all $F_3$ families with that actually obtained. The expected may be calculated from the figures given in the last column in Table 5. It was obtained as follows:

$$\frac{(56x1)+(52x2)+(39x1)+(65x2)+(61x4)+(48x2)+(92x1)+(88x2)+(76x1)}{16}=63.3$$

The average percentage of bunt of all 91 $F_3$ families was 64 (see Table 3).

The proof of the hypothesis may be summarized as follows:

(1) Close agreement of the observed transgressive resistant and transgressive susceptible types with the theoretical.

(2) The largest number of the 91 $F_3$ families fall into the bunt class with 61 per cent bunt, which was the calculated figure for the genotype AaBb.

(3) Close agreement of the observed mean percentage of bunt of all $F_3$ with the calculated.

The final proof of the transgressive inheritance was obtained by a test of the $F_4$ of two $F_3$ families from the extreme ends of the curve—that is, in bunt classes 9 and 15. Family 43 produced only $45.0 \pm 5.46$ in 43 $F_4$ rows compared to $54.5 \pm 7.44$ for White Odessa in the same year (see Table 3). Further, family 106 produced an average of 89.0 $\pm$ 4.12 per cent bunt in 46 $F_4$ rows compared to $57.5 \pm 6.41$ for Turkey-Florence in the same year.

*Reaction to an equal mixture of Ft-4 and Ridit tritici.*—The data showing the reactions of White Odessa, Turkey-Florence, and their $F_3$ progenies to an equal mixture of inoculum from physiologic races Ft-4 and Ridit *tritici* are given in Table 6. Nine rows of White Odessa produced an average of 83 per cent bunt, nine rows of Turkey-Florence 74 per cent, and 77 $F_3$ families 63 per cent.

a mixture of only two races the above-stated result is the general rule, it does not apply if more than two races are used (see Table 19, Holton and Heald, 1936). If numerous races are used the non-virulent races prevent the effectiveness of the virulent races to a much greater degree than if only two races are used—presumably by a mere dilution of the inoculum. Antagonism between the various races in a mixture might be suggested, but all the data known to the author suggest the effect of dilution of the inoculum as the real explanation.

Table 6. Distribution of Parents and $F_3$ Progenies When Inoculated with an Equal Mixture of Ft-4 and Ridit *tritici*.

| Parents and $F_3$ progenies | Bunt classes | | | | | | | Total No. of rows | Average percentage of bunt |
|---|---|---|---|---|---|---|---|---|---|
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | | |
| | 29-36 | 37-45 | 46-55 | 56-66 | 67-78 | 79-91 | 92-100 | | |
| | (Number of rows) | | | | | | | | |
| White Odessa | | | | | 2 | 6 | 1 | 9 | 83.4 |
| Turkey-Florence | | | | 1 | 6 | 2 | | 9 | 74.4 |
| $F_3$ | 2 | 11 | 14 | 23 | 13 | 7 | 7 | 77 | 62.7 |

The average percentage of bunt in the parents produced by the mixture does not vary a great deal from the percentage produced by the race to which the variety is the more susceptible. For instance, the percentage of bunt in White Odessa from the mixture of the two races is closer to that produced by Ft-4, whereas in Turkey-Florence it is closer to that produced by Ridit *tritici*. As stated previously, the percentages in Turkey-Florence produced by Ft-4 and Ridit *tritici* were 0.85 and 76.0, respectively; by the mixture it is 74 per cent. Though in

The reaction of the $F_3$ families to the mixture is quite similar to that obtained from Ridit *tritici*. In fact, the coefficient of correlation (r) between the reaction to Ridit *tritici* and the mixture in 76 $F_3$ families is $0.726 \pm 0.037$; the r value between Ft-4 and the mixture is $0.233 \pm 0.073$, and that between Ft-4 and Ridit *tritici* $-0.071 \pm 0.071$. Because of the lack of correlation between Ft-4 and Ridit *tritici*, it may properly be concluded that the resistance to these two races is controlled by entirely different genes. The rather high correlation between Ridit *tritici* and the mixture merely indicates that the resistance to the mixture of the two races is largely controlled by the factors which govern the resistance to Ridit *tritici*. Because, as was pointed out earlier, the reaction to Ft-4 is controlled by at least four factors and that of Ridit

*tritici* by two, there are at least six genes operative in the resistance to the mixture.

SUMMARY

1. White Odessa, Turkey-Florence, and their progeny were studied for their reaction to Ft-4 and Ridit *tritici*, physiologic races of *Tilletia tritici*.

2. White Odessa is highly susceptible and Turkey-Florence highly resistant to Ft-4. In 108 $F_3$ families neither the resistance of Turkey-Florence nor the susceptibility of White Odessa was recovered, as was proved by a study of the $F_4$ from extremes of resistant and susceptible $F_3$ lines.

3. The exact number of genes controlling resistance to Ft-4 could not be determined. However, at least four, all cumulative in effect, would be necessary to explain the results.

4. Both Turkey-Florence and White Odessa are moderately susceptible to Ridit *tritici*.

5. Approximately 18.75 per cent $F_3$ families were more resistant than White Odessa and 18.75 per cent more susceptible than Turkey-Florence.

6. It is assumed that White Odessa is of the constitution AABB, which causes its plants to fluctuatte around a mean of 56 per cent bunt; and Turkey-Florence aabb, which causes its plants to flucutate around a mean of 76 per cent bunt.

7. The $F_3$ families segregated according to the following Mendelian ratio:

9 like White Odessa
3 more resistant than White Odessa
3 more susceptible than Turkey-Florence
1 like Turkey-Florence

8. There is a close agreement between the calculated mean percentage of bunt in all $F_3$ families and the percentage actually obtained.

9. Transgressive inheritance in reaction to Ridit *tritici* was definitely proved by a test of several $F_4$ lines.

10. The coefficient of correlation between the reaction of 76 $F_3$ families to Ridit *tritici* and a mixture of Ft-4 and Ridit *tritici* is $0.726 \pm 0.037$; the r value between Ft-4 and the mixture is $0.233 \pm 0.073$, and that between Ft-4 and Ridit *tritici* $-0.071 \pm 0.071$.

11. It is suggested, on the basis of the correlations, that the resistances to Ft-4 and Ridit *trittici* are controlled by entirely different genes. The high correlation between Ridit *tritici* and the mixture indicates that the resistance to the mixture of the two races is largely controlled by the factors which govern the resistance to Ridit *tritici*.

12. Since the reaction to Ft-4 is controlled by at least four factors and that of Ridit *tritici* by two, at least six genes are operative in the resistance to the mixture.

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# REACTION OF WINTER WHEAT TO PHYSIOLOGIC RACES OF *TILLETIA LEVIS* KUHN AND *T. TRITICI* (BJERK.) WINT.[1]

Alva Marion Schlehuber

Part I. The inheritance in winter wheat to physiologic races of *Tilletia levis* and *T. tritici.*

The studies reported in Part I are as follows: (1) a study of $F_2$ plants showing various degrees of smuttiness in two winter wheat crosses; (2) a study of the mode of inheritance of two winter wheats and their progeny to two physiologic races of *Tilletia tritici*; (3) a study of "abnormal" types of smutting; and (4) a comparison of two related winter wheats to 78 collections of *Tilletia tritici* and *T. levis.*

The results of these studies may be summarized as follows: (1) The partially smutted $F_2$ plants of Oro x Hybrid 128 and White Odessa x Turkey-Florence were found to differ significantly in their $F_3$ reaction when inoculated with a composite mixture of physiologic races of the bunt organism. The higher the degree of smutting on the $F_2$ plant the more susceptible the $F_3$ proved to be. For the full text of points 2-12, see the previous article in this issue. (13) An "abnormal" smutting was observed in Turkey-Florence when inoculated with Ft-4. In this peculiar type of smutting the florets are very much dwarfed and sterile, and the amount affected varies from a single flower to the whole head, often appearing on one side only. (14) Ridit and Turkey-Florence, red- and white-seeded sibs, respectively, were tested for their reaction to 78 collections of bunt. The average reaction of Turkey-Florence to all 78 collections of bunt was 3.2; that of Ridit 4.8. Sixty rows of Turkey-Florence were smut-free or produced only a trace of bunt, whereas but two rows of Ridit escaped. It is suggested that the two varieties carry major factors in common for resistance but that Turkey-Florence carries additional factors to 61 out of the 78 collections.

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[1] Abstract of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Agriculture (Agronomy), State College of Washington (1938). Published as follows: "Can Different Degrees of Bunt Resistance Be Recognized in $F_2$ Plants," *Jour. Amer. Soc. Agron.*, XXVIII (1936), 266-70; "Studies in the Effect of Bunt, *Tilletia tritici* and *Tilletia levis*, on Wheat," *Phytopath. Zeitschrift,* X (1937), 614-32; and "The Inheritance of Reaction to Physiologic Races of *Tilletia tritici* (Bjerk.) Wint. in a Winter Wheat Cross," *Research Studies of the State College of Washington,* VI (1938), 75-96.

Part II. Physiological studies on the effect of bunt on wheat.

These studies were attacked from two angles: (1) the effect of bunt on winterhardiness; and (2) the effect of bunt on rate of growth of wheat seedlings.

These results may be summarized as follows: (1) The results of a freezing experiment in which three varieties of winter wheat—Oro, Ridit, and Heils Dickkopf—were inoculated with three physiologic races A, E, and G of *Tilletia tritici* from Halle/Saale, Germany. The freezing injury of the inoculated series was compared with that of adjacent control series. The freezing injury of the inoculated series always exceeded that of the control, but the differences between control and inoculated series were not always large enough to be considered significant as measured by Fisher's F value. (2) The biggest difference between control and inoculated series was found in Oro when inoculated with race E, to which Oro is highly resistant. There was also a large difference between the control and the series inoculated with race G, to which Oro is also highly resistant. This difference, though significant, was not highly significant, as with race E. (3) The studies of the effect of bunt on the rate of growth of wheat seedlings show that whether there is a depressant or a stimulating effect of the bunt race on the wheat seedlings depends on the variety of wheat, the physiologic race of bunt organism, and the stage of growth the plant has reached. At the end of 50 days there was a marked relation between the dry weights of the plants and the amount of bunt produced. The greater the susceptibility the higher the dry weight.

# OXIDATION-REDUCTION POTENTIALS OF ARSENATE-ARSENITE SYSTEMS IN SAND AND SOIL MEDIUMS[1]

CLARK M. KEATON

Investigations of the effect of arsenical spray residues on orchard soils and of the effect of certain treatments on the toxicity of the arsenic residues revealed an apparent correlation between the oxidation-reduction potential of certain treated soils and their ability to support plant growth. To ascertain the nature of this correlation, a basic study was undertaken of the oxidation-reduction potentials of arsenate-arsenite systems under different soil conditions with special reference to the iron, aluminum, and colloidal clay content of the soils.

In oxidation-reduction reactions, oxidation is considered to be the assumption of positive or the loss of negative electrical charges, or fundamentally the loss of electrons by atoms or ions, whereas reduction is the assumption of negative or the loss of positive charges, or fundamentally the gain of electrons by atoms or ions. This form of reaction produces a potential known as the oxidation-reduction potential or redox potential which is manifested by the production of an electrical current.

The oxidation-reduction potential of the arsenate-arsenite system which is suspended in sulfuric acid and is measured by the use of a platinum electrode in conjunction with a saturated calomel electrode may be derived from theoretical considerations of the calomel arsenate-arsenite cell, and may be written

$$E = E^\circ + \frac{RT}{2F} \ln \frac{[H_3AsO_4]\,[H^+]^2}{[H_3AsO_4]}$$

By substituting the mass-action constant K of the electrode reaction

$$H_3AsO_4 + 2H^+ + 2e^- \rightarrow H_3AsO_3 + H_2O$$

at a hydrogen ion concentration of zero, the equation may be simplified to

$$E = K + \frac{RT}{2F} \ln \frac{[H_3AsO_4]}{[H_3AsO_3]}$$

[1] Abstract of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Agriculture (Agronomy), State College of Washington (1938).

Arsenate-arsenite systems were established under different conditions and their redox potentials were determined. The potentials were studied in the following experiments: a series in which the ratio of arsenate to arsenite was varied in quartz sand ,in a sandy soil, and in a soil of high clay content; a second series in quartz sand, in a sandy soil, and in a clayey soil in which the iron content was varied, but the original ratio of arsenate to arsenite was established as unity; a third series in sandy soil and clayey soil in which the colloidal content was increased by additions of extracted colloid to its homologous soil with the original ratio of arsenate to arsenite as unity.

The redox potential of the arsenate-arsenite system in the pure quartz sand solution conformed with the theoretical formula. The slope of the curve was 0.029 with a value of 0.557 being obtained for the normal oxidation potential at a temperature of 21°. From these values, the mass action constant of the oxidation-reduction reaction was calculated to be $9.77 \times 10^{18}$. On the addition of a soil medium to the system, there is an interference due to the complexity of the medium, so that the potential is no longer a direct function of the arsenate-arsenite system alone. The complexity of the soil medium, because of the many different oxidizing or reducing compounds which may be present in it and which are unmeasurable in many instances, is such that the potential can be considered only as representing the particular soil system as a whole, irrespective of any individual oxidants or reductants. In the two soils studied, the clayey soil had a lower redox potential than the sandy soil, and the result was that in the latter there was a greater tendency for arsenic to be present in the form of arsenate. In both soils arsenic was fixed by adsorption and combination, but it was observed that a higher percentage of arsenate than arsenite was fixed by these soils.

The addition of iron to the system when the original ratio of arsenate to arsenite was unity increased the redox potential independent of the medium used. The effect of the medium was reflected in the magnitude of potential and in the existing ratios of arsenate to arsenite. The oxidation of arsenite to arsenate upon the addition of one gram of iron was 5.04 per cent in the quartz sand, 3.70 per cent in the sandy soil, and 1.95 per cent in the clayey soil. This difference in the percentage oxidation is probably due to two factors: the amount and nature of the colloidal fraction caused a more stabilized system, and the potential of the medium. The total fixation of arsenic by the iron was 2.5

mgs. per gram of iron, irrespective of the medium used.

In the pure quartz sand medium, a rapid increase in the potential indicated a completion of the reaction

$$2Fe^{+++} + H_3AsO_3 + H_2O \rightarrow 2Fe^{++} + H_3AsO_4 + 2H^+$$

with a corresponding preferential adsorption of arsenite over arsenate. In the soil medium this point of inflection was not obtained.

Aluminum had no influence on the redox potential of the system regardless of the medium. The only change in the systems was a slight fixation of arsenic by adsorption. This fixation amounted to 0.16 mgs. of arsenic per gram of aluminum.

In the two soils studied, the colloidal fraction possessed a greater reducing capacity and a lower potential than the soil from which it was extracted. Thus the redox potentials in both systems decreased with a corresponding reduction of the arsenate to the arsenite as the colloidal content was increased. Although the reducing capacity of the two extracted colloids was similar, the degree of arsenic fixation varied. The colloid extracted from the clayey soil fixed 1.985 mgs. of arsenic per gram, whereas that from the sandy soil fixed 2.598 mgs. of arsenic per gram. This difference may be due to the fact that a predominating factor in the potential is the combination of the chemical nature and particle size of the soil material, whereas the arsenic fixation is due to the chemical composition and nature of the colloidal micelle.

The redox potential of the soil will be a function and a summation of many factors: the chemical nature and characteristics of the different soil separates with special reference to the clay fraction, the amount and nature of the organic matter, and any soluble salts that may be present in the soil. Because of this complexity, the potential cannot be considered as that of an individual system but must be regarded as a function of many complex interlocking systems, and the concentration of oxidant and reductant must be considered to be the sum of the concentration of all oxidizing and reducing elements or compounds in the soil, and $E^\circ$, the algebraic sum of the individual potentials.

The effect of certain soil treatments on the arsenical spray residues may be interpreted on this basis. The beneficial effects produced by the addition of iron to soils poisoned by arsenical spray residues are due primarily to the fixation of arsenic by iron. The greater benefit obtained with the oxidized forms of iron results from the oxidation of the arsenite to the arsenate form, which is fixed to a higher degree by the soil.

# THE INTERFACIAL TENSIONS OF SOME MERCURY-HYDROCARBON OILS

FRITZ A. HEDMAN[1]

The surface tensions at oil-mercury interfaces were measured, several samples of each of two types of oil being used. These oil types were motor lubricating oils and refined medicinal oils. Beginning at a temperature of 25° C. measurements were made at 25-degree intervals to 125° C.

The two types of oils yielded characteristically different interfacial tension vs. temperature curves. The medicinal oils show, at 25° C, an interfacial tension with mercury of about 365 dynes per centimeter. As the temperature increases, this value decreases in an approximately linear fashion to about 350 dynes/cm. at 125° C.

The motor oils exhibit lower surface tensions at the oil-mercury interface, varying with different samples from 339 dynes to 350 dynes/cm. at 25° C. As the temperature is increased, the interfacial tension values decrease at varying rates, some decreasing not at all or increasing between 50° and 75°; but all decrease very rapidly above 100° C. At the higher temperatures the measurements on the motor oils also showed that the interfacial tension of a given system dcreased as the period of contact, oil to mercury, was prolonged.

From the data obtained, it was inferred that the motor oils were richer in adsorbable surface active components than are the medicinal oils.

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[1] Abstract of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Chemistry, State College of Washington (1934). Published in part as "The Interfacial Tensions of Some Mercury-Hydrocarbon Oil Systems," *Journal of Physical Chemistry*, XLI (1937), 485-91.

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RESEARCH STUDIES of the STATE COLLEGE OF WASHINGTON

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# DELINQUENCY AREAS IN SPOKANE, WASHINGTON

H. ASHLEY WEEKS, *Instructor in Sociology*, and
MARGARET G. SMITH, *Research Fellow in Sociology*

In 1929 Dr. Clifford R. Shaw published a monograph called *Delinquency Areas*,[1] a study of the geographic distribution of school truants, juvenile delinquents, and adult offenders in Chicago. Later Doctor Shaw expanded the Chicago study somewhat and carried the same procedure into six other American cities: Philadelphia, Pennsylvania; Richmond, Virginia; Cleveland, Ohio; Birmingham, Alabama; Denver, Colorado; and Seattle, Washington.[2] In each of these seven cities the distribution of juvenile delinquents showed the same general geographic configuration of cases. In each instance the highest concentration appeared in or adjacent to the central business area and the major industrial developments, and the lowest concentration appeared in the outlying districts. Not only did each city show a similar configuration of cases, but rates of delinquency by unit areas confirmed the impression of concentration in the central areas. The rates were highest in the central districts and decreased as the periphery of the city was approached.[3]

These studies have proved very fruitful to the student of juvenile delinquency, because variations in the number of delinquents and the rates of delinquency have an important bearing on the investigation of causative factors and on the determination of what treatment shall be accorded the individual delinquent. It cannot be gainsaid that the probability of a child's becoming delinquent is much greater in areas of high concentration of delinquency, because frequency of contact between delinquents and non-delinquents alone would justify an expectation of still higher delinquency rates; whereas in sections of the city where cases are more widely dispersed these contacts would not be so frequent. Behavior is a product of the total situation. Therefore study

[1] Clifford R. Shaw, *Delinquency Areas*, Chicago (University of Chicago Press), 1929.

[2] See National Commission on Law Observance and Enforcement, *Report on the Causes of Crime*, II (U. S. Government Printing Office, 1931), pp. 140-88.

[3] *Ibid.*, pp. 25-57, 146-52, 153-58, 160-65, 167-72, 174-79, 181-87, and Shaw, *Delinquency Areas, passim.*

of a homogeneous culture area ought to shed light on the factors making delinquency prevalent within that area.

As part of a broader study of delinquency in Spokane,[4] the writers have attempted to determine the distribution of delinquency and rates of delinquency, and to compare this distribution with the pattern found in the cities mentioned above. There were some reasons to believe that Spokane would not conform to the general configuration of the other cities. Spokane has a smaller total population than any of those cities, with a higher percentage of native whites and a smaller percentage of foreign-born and Negroes. It has a smaller percentage of illiteracy and has a larger percentage of persons from seven to eighteen years of age in school. There is also in Spokane a higher percentage of married males and females over fifteen years of age.[5] All these factors have been found in other studies to have some bearing on delinquency rates.

A schedule was filled out for each delinquent who had contact during 1937 with the Spokane County Juvenile Court, in either an official or an unofficial capacity.[6] There was a total of 515 cases—420 males and 95 females. Because the court has jurisdiction over the entire county, however, it was necessary to exclude all cases outside the city limits, so that there were only 330 cases of males and 71 cases of females used for the city study. From the addresses of these cases a spot map was made of all delinquents. The spatial distribution of these cases may be noted on Map I. In general, the highest concentration of cases appears to be in the areas near the business district and adjoining industrial property.

This tendency for the areas of highest concentration to be closest to the center of the city is further indicated if some analysis of the spatial distribution of cases is made in terms of the number of cases per square mile. If the spot map is divided into four zones by means of concentric circles at radii of one, two, and three miles from the corner of Sprague and Division Streets,[7] the concentration of cases within each zone may be ascertained (Map I).

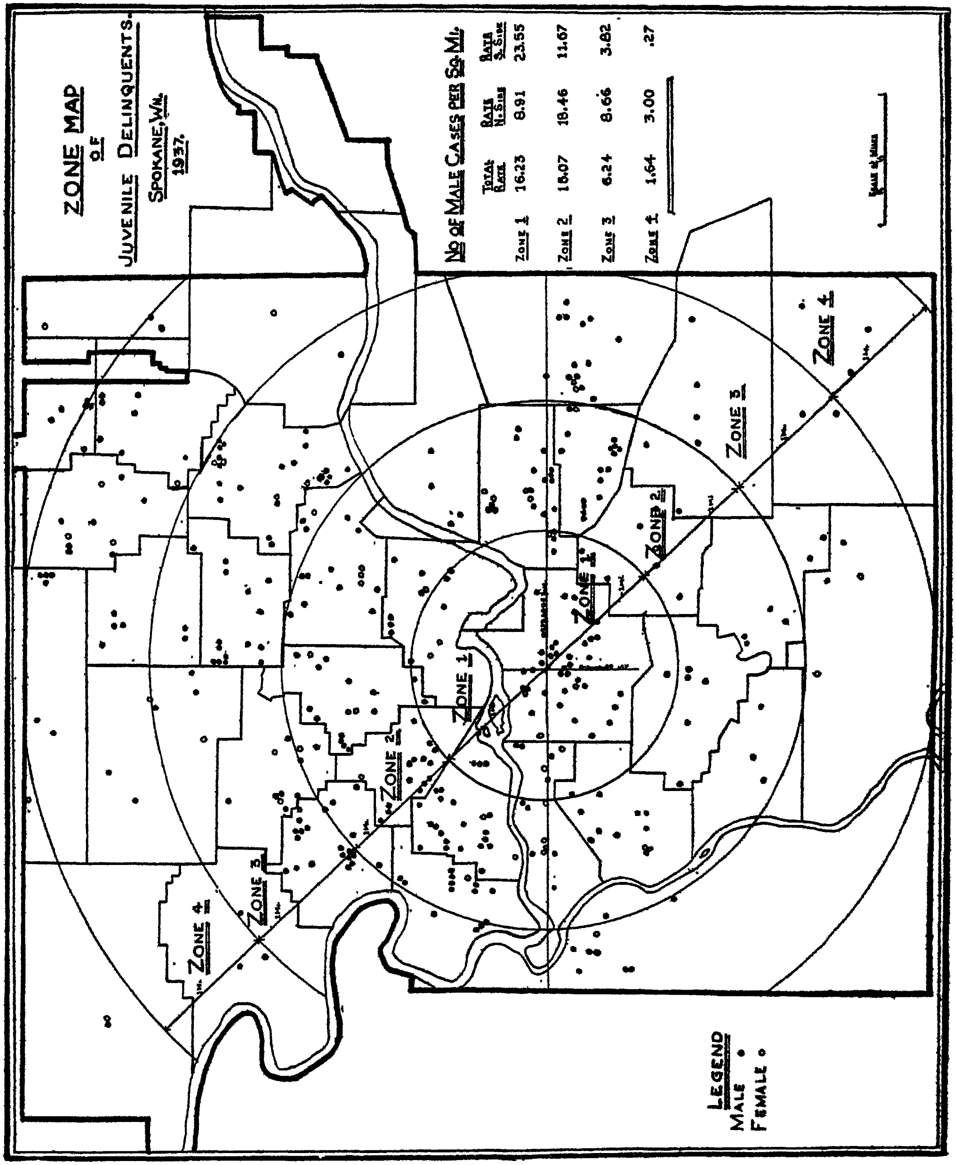
[4]Thanks are due to Judge R. M. Webster of the Spokane County Juvenile Court and Mr. H. W. Arvin, Probation Officer, for permission to use the records in the Juvenile Court Office.

[5]U. S. Census Bureau, *Population,* III (1930), Table 15, for each state mentioned above.

[6]Unofficial cases are those which are brought into the Juvenile Court Office, and there advised by the probation officer, but do not appear before the judge in court.

[7]This corner seemed a reasonable point to take because the city is numbered east and west, and north and south from this point.

MAP I


ZONE MAP OF JUVENILE DELINQUENTS. SPOKANE, WN. 1937.
NO. OF MALE CASES PER SQ. MI.
TOTAL RATE | RATE N. SIDE | RATE S. SIDE
ZONE 1 16.23 8.91 23.55
ZONE 2 18.07 18.46 11.67
ZONE 3 6.24 8.66 3.82
ZONE 4 1.64 3.00 .27
ZONE 1
ZONE 2
ZONE 3
ZONE 4
LEGEND
MALE •
FEMALE ∘

Cases of male delinquency only have been used in compiling the following data, as there are too few female delinquents in any one year to be divided spatially with any statistical significance.

Analysis of the spatial distribution of the male cases, on the basis of division into zones, shows several interesting characteristics. The concentration of cases decreases progressively as the distance from the central point is increased—Zones 1, 2, 3, and 4 having, respectively, 16.23, 15.07, 6.24, and 1.64 cases per square mile.[8] Presented cumulatively, 51 cases, or 15.45 per cent of the total, lie within the first zone, which comprises 6.25 per cent of the total area; and 193, or 58.48 per cent of the cases, lie within the first two zones, which together comprise only 25.00 per cent of the total area. Thus, on the basis of numbers per square mile, there is a significant relationship between concentration of cases and their location in the city.

Because of certain economic differences between the northern and southern sections of the city, it seemed advisable to make further analysis of the spatial concentration. Fewer delinquents per square mile were found in the southern half of every zone except Zone 1, in which there are 23.55 cases per square mile, as compared with only 8.91 cases per square mile in the northern section. This fact, however, can be explained on the basis of the characteristics of the zone. In this first zone almost all the retail business area and a large section of the area of cheap hotels and rooming houses lie south of Sprague Street, whereas north of Sprague Street there is a low density of population due to the concentration of railroad and industrial property and the space occupied by the Spokane River. In Zones 2, 3, and 4, respectively, the numbers of cases per square mile are 18.46, 8.66, and 3.00 on the north side, as compared with 11.67, 3.82, and 0.27 on the south side, every zone showing a higher concentration on the north side than on the south side (see Map I).

It should be noted, however, that the incidence of delinquency per square mile does not take into consideration the density of juvenile male population in each zone. In no instance is allowance made for the land which remains undeveloped or which has been used for other purposes than for residential property. On the basis of general observation, however, it seems that such unpopulated land is rather evenly distributed over the city as a whole. As has been pointed out, a large

[8] Six cases lie outside the fourth zone on the periphery of the city and have not been included in these rates.

portion of the land near the center of the city is devoted to non-residential property; on the other hand, a large portion of the area on the periphery is either undeveloped land or railroad and industrial property.

In order to make a more accurate study of the distribution of delinquency, the number of delinquents in a given area must be related to the juvenile population aged eight to eighteen.[9] In most of the larger cities, at the present time, the U. S. Census has designated as units of measurement relatively small homogeneous areas, called census tracts. These areas are enumerated for age, sex, and other differentials. Unfortunately, Spokane has not been divided into census tracts, and some other unit had to be used. The only relatively homogeneous units dividing the city of Spokane are the various elementary school districts; consequently, these were used. School districts are not, strictly speaking, homogeneous, but they are sufficiently homogeneous in regard to population and environmental characteristics in Spokane to serve the purpose of this study reasonably well.

The juvenile population for each of these school districts then had to be ascertained. This was accomplished by adding to the number of individuals aged eight to eighteen enrolled in the elementary schools,[10] the number of high school students residing in each elementary school district.[11] It should be noted here that this school population is an estimate of the population from eight to eighteen years of age, and not the actual population. In the first place, no account was taken of the population attending the parochial schools. In individual school districts this may have raised or lowered the rates, depending upon the proportionate numbers of Catholics living in a particular school district. However, from a rather superficial observation, and from conversations with several persons well informed about the Catholic population in Spokane,

[9] The male juvenile population aged eight to eighteen is used rather than the total juvenile population because it is only these ages over which the Juvenile Court has jurisdiction.

[10] *Sixty-Second Annual Report of the Spokane Public Schools* (Spokane, Washington, 1937), pp. 38-42.

[11] The number of high school students residing in each elementary school district was determined by counting the number of addresses in these school districts which were reported on a questionnaire submitted to all the high and junior high school students in Spokane. Later a sample was picked at random from these questionnaires to use as a control group.

The authors wish to acknowledge their debt to the principals of the five Spokane secondary schools: Mr. Truman Reed, Mr. F. G. Kennedy, Mr. J. D. Meyer, Mr. H. G. C. Fry, and Mr. R. H. Knaack, without whose interest and coöperation this study could not have been carried out.

Thanks are also due to Dr. Orlo Maughan and Mr. Earl Carlson, whose coöperation greatly facilitated the completion of the tabulation of these data.

it was learned that there is a fairly even distribution of Catholics throughout the city. It was felt, therefore, that in all probability the rate secured for each school district would not have been altered significantly if this Catholic population had been included. In the second place, no attempt was made to determine the number of individuals who had left school. This might cause a more serious bias, because of the fact that the economically poor districts would have a greater proportion of the population unrepresented. An under-enumeration would, of course, cause a higher rate in particular districts. However, in Spokane almost 90 per cent of the persons sixteen and seventeen years of age are still attending school.[12] Computations were made to see what would be the situation if the 10 per cent not attending school should all be from certain poorer districts. Even so, the rates as a whole would not be altered significantly and the general pattern here presented would persist.

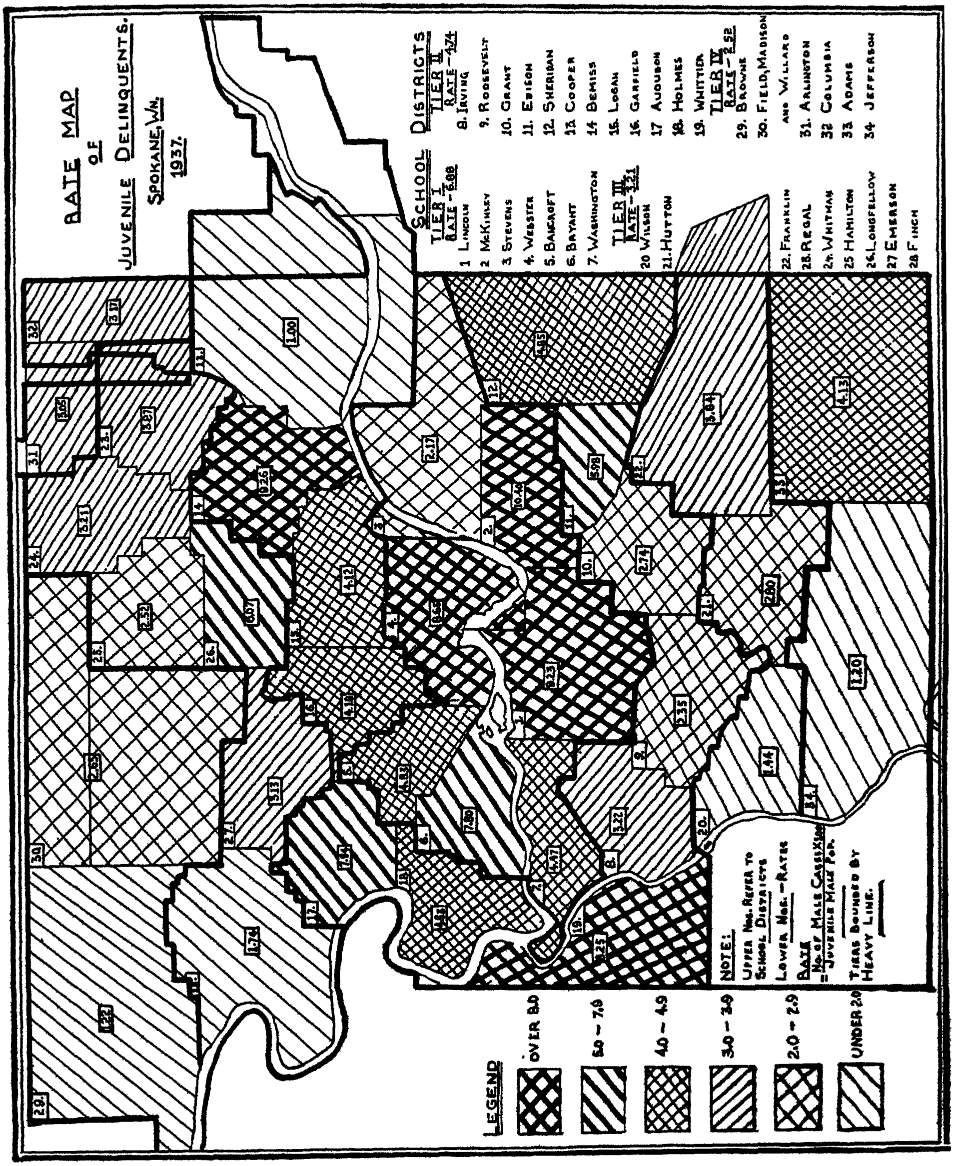
In the city as a whole there was a delinquency rate of 4.47 per hundred males. The rates of the individual districts had a range of 9.40. The lowest rate, 1.00 per hundred, was found in Cooper district on the northeast side of the city; the highest rate, 10.40, in McKinley district, just southeast of the retail store center.

School districts were then grouped together in tiers roughly conforming to the original zones. All school districts which included and immediately surrounded the center of the city were grouped in Tier I. The districts contiguous to Tier I were grouped together in Tier II; in like manner were formed Tiers III and IV. The delinquency rates in these four tiers of districts were found to be, respectively, 6.88, 4.74, 3.21, and 2.52 per hundred males. Thus, even with the use of the crude units with which it was necessary to deal, the delinquency rates decrease decidedly toward the periphery of the city (Map II). In other words, those districts adjacent to and including the business area have the highest rates, and those on the periphery have the lowest.

Within each tier of districts, however, there is a rather wide variation. In the first tier, the rates are as follows: Stevens, 2.17; Washington, 4.47; Bancroft, 4.83; Bryant, 7.80; Webster, 8.65; Lincoln, 9.23; McKinley, 10.40. It is significant that Lincoln district, which has the second highest rate, incorporates within its confines practically all of the retail business district (Map II). The standard error for this

[12] U. S. Census Bureau, *Population*, III (1930), Table 15, p. 1229.

MAP II


RATE MAP
OF
JUVENILE DELINQUENTS.
SPOKANE, WN.
1937.
SCHOOL DISTRICTS
TIER I
RATE – 6.88
1 LINCOLN
2 MCKINLEY
3 STEVENS
4. WEBSTER
5. BANCROFT
6. BRYANT
7. WASHINGTON
TIER III
RATE – 3.21
20 WILSON
21. HUTTON
22. FRANKLIN
23. REGAL
24. WHITMAN
25 HAMILTON
26. LONGFELLOW
27 EMERSON
28 FINCH
TIER II
RATE – 4.74
8. IRVING
9. ROOSEVELT
10. GRANT
11. EDISON
12. SHERIDAN
13. COOPER
14. BEMISS
15. LOGAN
16. GARFIELD
17 AUDUBON
18. HOLMES
19. WHITTIER
TIER IV
RATE – 2.52
29. BROWNE
30. FIELD, MADISON AND WILLARD
31. ARLINGTON
32 COLUMBIA
33 ADAMS
34 JEFFERSON
NOTE:
UPPER NOS. REFER TO SCHOOL DISTRICTS
LOWER NOS. – RATES
RATE = NO. OF MALE CASES X100 / JUVENILE MALE POP.
TIERS BOUNDED BY HEAVY LINE.
LEGEND
OVER 8.0
5.0 – 7.9
4.0 – 4.9
3.0 – 3.9
2.0 – 2.9
UNDER 2.0

whole series is ±.648, which would give an upper limit of 7.53 and a lower limit of 6.23. In other words, if chance alone operated, it would be possible to get a distribution as high as 7.53 and as low as 6.23 in another series of cases.

The second tier has the following rates: Cooper, 1.00; Roosevelt, 2.35; Grant, 2.74; Irving, 3.22; Logan, 4.12; Garfield, 4.18; Holmes, 4.53; Sheridan, 4.85; Edison, 5.98; Audubon, 7.94; Whittier, 8.25; Bemiss, 9.26. The standard error of this series is ±.393, the upper and lower limits thus being 5.13 and 4.35.

The rates in the third tier are: Wilson, 1.44; Finch, 1.74; Hamilton, 2.52; Hutton, 2.80; Emerson, 3.13; Whitman, 3.21; Franklin, 3.64; Regal, 3.87; and Longfellow, 6.07. This series has a standard error of ±.305, the upper and lower limits thus being 3.52 and 2.91. In the fourth tier the rates are: Jefferson, 1.20; Browne, 1.22; Field, Madison, and Willard,[13] 2.65; Arlington, 3.05; Columbia, 3.17; and Adams, 4.13. The standard error for this series is ±.489, the upper and the lower limits thus being 3.01 and 2.03.

When the formula for testing the differences between rates was applied to these data, it was found that, although the results were not conclusive, indications were that chance did not account for the differences.[14] Between Tier I and Tier II, there is a difference in rates of 2.14, which is greater than two times sigma. Likewise, between Tier II and Tier III, there is a greater difference than two sigma. The difference between Tier III and Tier IV, however, is less than two sigma. In spite of this it would appear reasonable to assume that this

[13] Field, Madison, and Willard were grouped together because of the smallness of the school population in Field and Madison, and the fact that these two schools do not have all the grades.

[14] There has been some criticism recently as to whether the usual formulae are applicable for testing the differences between rates. Error formulae assume that the selection is random and that the data vary independently. In census tract or school district data, neither of these conditions is fully satisfied. Geographic areas are not independent but are tied together "like bunches of grapes." Social data are, by their very nature, interrelated and not entirely independent. Until this controversy is settled, it would seem justifiable to use the customary methods, provided they are used with caution. Actually, of course, a test of significance does not mean that there is or is not a real difference between rates; all that is indicated is that, mathematically, chance could or could not have accounted for the differences. (See: Sophia M. Robison, *Can Delinquency Be Measured?* [New York: Columbia University Press, 1936], pp. 190-203; Frederick F. Stephan, "Sampling Errors and Interpretations of Social Data Ordered in Time and Space," *Journal of the American Statistical Association*, XXIX [March, 1934, Supplement], 165-66; Frank Alexander Ross, "Ecology and the Statistical Method," *American Journal of Sociology*, XXXVIII [1933], 509.)

difference is not due to chance alone (although it cannot be proved mathematically), because Tier IV does vary in the same direction as do the other three tiers.[15]

The observation that there is a difference between the north and south sides is also borne out when these sections are examined on the basis of rates. With the exception of Tier I, the rates are always higher on the north side than on the south side. Tiers II, III, and IV have rates of 5.42, 3.51, and 2.62, respectively, on the north side, as compared with 4.07, 2.55, and 2.44, respectively, on the south side. That Tier I has a rate of 8.34 on the south side as compared with a rate of only 5.53 on the north side may be explained by the fact that the southern section of Tier I includes the high-rate districts of Lincoln and McKinley, with a preponderance of business and industrial areas.

An attempt to interpret and give meaning to these findings raises certain questions: (1) What are the characteristics of these areas of high rates and how are they differentiated from the areas of low rates? (2) Why do the tiers assume the pattern of high to low rates? (3) Why are there exceptions within each tier? An examination and analysis of the various tiers and the separate districts within the tiers lead to some interesting conclusions.

Various explanations may be suggested to account for the fact that the highest rates of delinquency are to be found close to the center of the city. It seems obvious that in this section there is more opportunity for the individual to come into conflict with the law. Not only does the downtown area present to the potential delinquent such opportunities for excitement as shoplifting and sneaking into theatres, but the differential in police protection and enforcement between these areas and the outlying districts makes apprehension of all types of delinquency more likely. Coupled with this is the fact that most of the juvenile population in the central area must seek its recreation in the streets, inasmuch as the city has not built playgrounds or recreational parks in this area—probably because of the high value of the land for business purposes.

Doctor Shaw has attributed the incidence of high rates to the general disorganization within the central areas. These areas are characterized by a high mobility and a general instability which leads to a lack of parental, neighborhood, and other social controls. Certainly in Spo-

[15] The $X^2$ method was also used to test these differences. The test showed that a like distribution would occur but two times in a hundred except between Tier III and Tier IV, where a like distribution might be expected as frequently as twenty or thirty times in a hundred.

kane are found at least some of the factors which are typical of what have been called "Zones of Transition." [16]

High-rate districts in the central area are, generally speaking, areas of physical deterioration and poor housing because of the encroachment of business and industry on the older residential areas. Residences are rented rather than owned and frequently houses originally built for a single family have been converted into multiple-family dwellings. In many instances families supplement their income by taking roomers and boarders. At least such areas are usually inhabited by persons of low economic status, and by a high percentage of foreign-born. In Spokane this is true. On the basis of the control group, both the percentage of homes rented and the percentage of persons unemployed or employed on WPA follow the distributional pattern of delinquency. In the four tiers the percentages of rented homes are 54.76, 29.71, 24.87, and 15.41, respectively. The percentages of persons unemployed or at work on WPA are 6.55, 4.93, 2.67, and 5.36, respectively. The percentages of foreign-born are 29.73, 23.27, 17.59, and 35.71, respectively. It is interesting that the two latter distributions reverse the trend in the fourth tier. This is probably accounted for by the fact that some foreigners and families of low economic status move out to the periphery of the city to take advantage of low land values and low taxation to build some kind of cheap living accommodations. Finally, broken homes were found to be much more prevalent in the central areas than in the city as a whole. The percentages of homes broken by divorce, desertion, separation, or the death of one or both parents run from 35.48 in Tier I to 18.46 in Tier IV. In Tier II and Tier III the percentages are 25.64 and 22.60, respectively. All these factors have been found to correlate positively with juvenile delinquency, perhaps because they themselves contribute to personality maladjustment or because as, Doctor Shaw maintains,[17] they are manifestations of the lack of social control which, in the process of city growth, becomes prevalent throughout the central areas.

Within each of the tiers there are certain districts which have a wide deviation from the average rate for that tier. In an attempt to explain this deviation, some effort has been made to determine the incidence of factors which have been generally recognized as having a positive relation to delinquency.

[16] National Commission on Law Observance and Enforcement, *op. cit.*, p. 62 ff.
[17] *Delinquency Areas*, p. 205.

Within the first tier the outstanding deviation from the general pattern is in Stevens district, which has a delinquency rate of only 2.17, as compared with 6.88 for the tier as a whole. It is significant that, if Stevens is omitted, the rate for the whole tier is raised to 7.52. Why Stevens has such a low rate is difficult to determine, as its physical appearance is not much better than the high-rate districts which are adjacent to it. As a tentative explanation, however, it may be noted that it has a lower rate of broken homes and a lower percentage of homes rented than is true for the tier as a whole. The broken-home rate is 29.79, as compared with 35.48, and the percentage of homes rented is 34.04, as compared with 54.76 for the whole tier. Moreover, a study of the delinquencies committed in this area suggests that there is a more serious problem of delinquency than the rates would indicate. All the offenses are property offenses, and in all but one instance the delinquents are previous offenders. It may be noted, too, that Stevens and Washington district, with the next lowest rate in this tier, run to the eastern and western boundaries of the city. Stevens in the eastern section extends to the city limits. Washington in the western section extends to High Bridge Park, where there is, at the confluence of the Spokane River and Latah Creek, a deep ravine which has limited city growth in a westerly direction. Thus in a sense these two districts partake of the nature of both central and peripheral areas. This hypothesis can be tentatively substantiated by dividing Washington district in two. Assuming a fairly even distribution of the juvenile population, the rate for that portion of Washington nearest the city center is raised to 6.67 because most of the delinquents live in the eastern half of the district. The delinquents in Stevens all live in the western third of the district, that nearest the city center. Even on the assumption that half of the juvenile population lives in this third of the area the rate for Stevens is doubled, being raised from 2.17 to 4.35.

Tier II is an area of contrasts. Not only does the southern portion differ from the northern, as was pointed out, but both in the south and the north certain districts differ considerably from the general rate for the district as a whole. Throughout Tier II there are fairly good residential districts with low rates contrasted with poor economic districts with high rates. The three districts which deviate most markedly from the low-rate districts in the southern section of this tier are Edison, Sheridan, and Whittier. Edison and Sheridan lie between the Northern Pacific and the Great Northern railroads and are crossed by the Union

Pacific. This area includes a high proportion of deteriorated property and evidences of low economic status. This part of Tier II is in strong contrast to the residential districts of Irving, Grant, and Roosevelt and seems to be analagous to the central area of Tier I. In Edison and Sheridan the percentages of foreign-born, of unemployed and WPA workers, and of broken homes are all greater than in the tier as a whole.[18] Whittier, which lies on the western border of this tier, has the unusually high delinquency rate of 8.25; but when analysis is made of the nature of the offenses committed it is observed that they are all merely childish pranks rather than serious delinquencies. The majority of the offenders were reported by railroad police for using railway signals as targets. Further, the lowest age distribution occurs in this district; two-thirds of the delinquents are under twelve years of age, and all but one are first offenders.

It is interesting that the Roosevelt district, which is probably the best residential district in Spokane, had only six delinquents during 1937, all of whom were apprehended for traffic violations.[19]

In the northern section of this tier, Audubon and Bemiss are found to deviate quite markedly, having rates of 7.94 and 9.26, as contrasted with 5.42 for the northern section as a whole. Audubon has a better physical appearance than is typical of high-delinquency areas. It is also characterized by a comparatively low rate of foreign-born, unemployment, and broken homes. On the basis of the data which are at present available there seems to be no adequate explanation for the high rate of delinquency in this district. It is significant, however, that during 1937 seven boys were brought into court from this district on one trespassing offense. That this incident weights the rate for the district is shown by the fact that if these cases were excluded the rate would be lowered to 5.16, which conforms almost exactly to the average for the northern section of this tier.

Bemiss, for the most part, is a district of very low economic status. In this district 11.11 per cent are unemployed or are on WPA, as compared with 4.93 per cent for the tier as a whole. Although there are some streets which present no evidences of deterioration, the district

[18] The percentages are, respectively: 30.77, 6.78, and 30.43 in Edison and Sheridan as contrasted with: 23.27, 4.93, and 25.64 for the tier as a whole.

[19] No mention is made of the extremely low rate for Cooper district in this tier or of the high rate for Columbia in Tier IV, because both the number of delinquents in these areas and the size of the juvenile male population are too small to assure that the rates are significant.

is, generally speaking, rather typical of interstitial zones. These are areas where poor property and industrial property is encroaching on the better residential districts. Railroad lines cut through both the center and the southern sections of the area, and a considerable proportion of the district is devoted to light industrial property. Many of the homes in that part of the area which adjoins the railroad and industrial property are hardly more than shacks and present a very deteriorated appearance.

The districts in the third tier show very little deviation with exception of Longfellow, which has a rate of 6.07, almost double that for the tier as a whole. Certain contrasts are evident as far as the physical appearance of this district is concerned. The northern section is characterized by new residential developments, whereas the southern part presents a deteriorated appearance. That the district is, in general, one of low economic status is evidenced by the percentage of persons unemployed or working on WPA, which is 9.52, as compared with 2.67 for the whole tier. The rate of foreign-born in Longfellow is also somewhat higher than in the other districts: 25.00, as compared with an average rate for the tier of 17.59. It is possible that there has been some under-enumeration of the juvenile population in this area, for a parochial school that is in the district may conceivably draw a high proportion of its students from the immediate vicinity. If so, the rate might be materially lowered by the increase in the estimated juvenile male population.

In Tier IV Adams has a rate of 4.13, as contrasted with an average rate for the tier of 2.52. This district presents quite a different appearance from the adjoining low-rate districts on the south side. Though parts of the area are composed of fairly good residential property, a large proportion is made up of rather poor frame dwellings. Here 24.39 per cent of the homes are rented, and 7.14 per cent of the heads of families are unemployed or are on relief, as compared with 15.41 and 5.36 for the entire tier. The outstanding factor which has been measured in this district is the unusually high rate of broken homes. Adams has a broken-home rate of 34.15, as compared with only 18.46 for the tier as a whole. These factors may help to explain the rate in this district.

Though the data here presented have been gathered from reliable sources of information and have been checked for accuracy whenever possible, the resulting conclusions must be recognized as merely tenta-

tive. Because of the small numbers used in calculating percentages for some of the factors in individual school districts, the figures reported should not be taken too literally but only as approximations of the actual incidence of these factors. Further investigation and data for other years might make it necessary to reformulate some of these conclusions.

It is significant, however, that the concentration of cases closely conforms to that found by Doctor Shaw in the American cities which he studied.[20] In Spokane, as in each of the six cities studied by him, the highest rates are in the areas adjacent to the central business district, whereas the lowest rates are, in general, in the residential districts farther removed from the commercial and industrial developments. This fact may be due, as Shaw contends, to the "process of differentiation and segregation resulting from the natural growth and expansion of the city" [21] or to the more specific factors discussed above, such as low economic status, cultural conflicts of children of foreign-born parents, and unstable home situations.

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[20] *Supra*, p. 107.

[21] National Commission on Law Observance and Enforcement, *op. cit.*, p. 187.

# A COMPARISON OF AN ENGLISH CLASSIFICATION TEST AND A PSYCHOLOGICAL EXAMINATION AT THE COLLEGE LEVEL[1]

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The American Council on Education "Psychological Examination for College Freshmen," [2] frequently referred to as the Thurstone test, has been given to entering freshmen at the State College of Washington for eight years. During about the same period the English Department of the State College has developed a comprehensive type of English classification test, one portion of which (Part II) is similar to tests used in many higher educational institutions. The particular form of this English test used in the present study consisted of three parts, as follows: Part I, a silent-reading test, 71 items; Part II, composition factors (spelling, grammar, punctuation, and a little rhetoric), 184 items; Part III, a factual test in English and American literature, 60 items. This English test has proved very satisfactory for the purpose for which it is intended: namely, to classify entering freshmen in their English courses, both in composition and in literature.

The first time that the Thurstone test was given at the State College of Washington was September, 1930. At the end of the college year, a correlation was worked out between the psychological-test scores and the course grades of the approximately 850 freshmen who had entered in September and had remained in the institution both semesters.[3] According to the Pearson formula,[4] the correlation coefficient was .43.

For the present study, a sample of two hundred freshmen entering in September, 1935, was taken. The names of the freshmen entering in that year were already arranged alphabetically, and we used the scholastic records of the first two hundred students who had remained for the

[1] The author is indebted to Doctor Carl I. Erickson, Associate Professor of Psychology, and Doctor Paul Fendrick, Assistant Professor of Education, for helpful criticisms, and to Doctor Paul P. Kies, Secretary of the English Department, for the scores of the students in the English classification test.

[2] Prepared by L. L. Thurstone and Thelma G. Thurstone under the auspices of the American Council on Education, Washington, D.C.

[3] For the computation of the course-grade average of each student, the grade-point system of the State College of Washington was used. Three points are counted for each hour of A, two for each hour of B, one for each hour of C, and none for K (the lowest passing grade) and for F (a failure).

[4] Readers who wish an explanation of the Pearson formula should consult a book on statistics, such as L. L. Thurstone's *The Fundamentals of Statistics* (New York, 1925), Chap. 23.

entire freshman year of college work. According to the Pearson formula, the correlation between the psychological-test scores and the scholastic performance of the freshman year[5] was $.47 \pm .037$. This coefficient of correlation is practically the same as that obtained with the entire freshman class of 1930, being only .04 higher than the one secured earlier. The sample of two hundred, therefore, seems adequate for the present study.

The correlation coefficient between the English classification test of these same two hundred freshmen and their scholastic performance in all their subjects during their first year in college (according to the grade-point system explained in footnote 5) was found to be $.51 \pm .035$. This correlation is a little higher than, but close to, the correlation between the psychological score and the average grade points.

Part I of the English test, including 71 items, has proved to be a very good test of reading ability. It is generally recognized that reading tests are a good measurement of ability to do college work. A correlation between this part of the English test and the average grade points in all courses of the first college year was worked out, the Pearson formula being used. The correlation coefficient was $.68 \pm .025$. This is a rather high correlation for a test of this sort; it is .21 higher than the correlation between the Thurstone test and scholastic performance, and is .19 higher than the correlation between the English test as a whole and scholastic performance.

Other correlations which were obtained include the coefficient of $.73 \pm .021$ between the Thurstone test and Part I of the English test, and the coefficient of $.84 \pm .013$ between the Thurstone test and the English test as a whole. This latter correlation is rather high, especially in view of the fact that the two tests are intended to serve different purposes.

We desired to compare these two tests a little further and in a little different way. Thinking that for our purposes a larger sample might be advantageous, we increased the sample from two hundred to include six hundred of the freshman class entering in September, 1935, selecting them in the same way in which the two hundred were chosen. The

[5] Because the grade-point system used in this institution makes no differentiation between a K (the lowest passing grade) and an F (failure), it seemed advisable for this study to range grade points so that K would have more value than F. Therefore we allowed four grade points for each hour of A, three for each hour of B, two for each hour of C, one for each hour of K, and none for each hour of F.

percentile ranks of these six hundred students in the English classification test were divided as nearly as possible into quintiles. Each quintile was subdivided into three groups according to the average grade points made in the freshman year.[6] The distribution of cases according to quintiles in the English classication test and according to average grade points is presented in Table I. A grade-point average of less than one is

TABLE I

Distribution based on percentile scores in English classification test. "No." (in the left-hand column for each quintile) represents number of cases.

| Average Grade Points | 1-20% | | 21-40% | | 41-60% | | 61-80% | | 81-100% | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| 0- .99 | 71 | 52 | 40 | 37 | 27 | 23 | 21 | 18 | 8 | 6 |
| 1-1.99 | 66 | 48 | 63 | 59 | 78 | 69 | 84 | 72 | 77 | 62 |
| 2-2.99 | 0 | 0 | 4 | 4— | 9 | 8 | 12 | 10 | 40 | 32 |
| Total | 137 | 23 | 107 | 18 | 114 | 19 | 117 | 19 | 125 | 21 |

unsatisfactory; and 75 persons in the first quintile, or over half of the cases, failed to meet a satisfactory standard. Sixty-six in this quintile, or fewer than half, did average work (a grade-point average of 1 to 1.99), and none did superior work (a grade-point average of 2 or more). On the other hand, of 125 cases in the fifth quintile, only 6 did unsatisfactory work; whereas 77 placed in the large middle group (which includes 368 of the 600 students), and 40, or almost a third, did superior work. The last-mentioned fact is highly significant, inasmuch as only 65 of the 600 students achieved an average of 2 or more grade points; in other words, nearly two-thirds of all the students who made an average of 2 or more grade points (40 out of 65) are in the highest quintile in the English test.

With the percentile rank in the Thurstone test, the same procedure was followed. As shown in Table II, the distribution is very similar to that of Table I.

The next procedure was to take the distribution into quintiles of the psychological test as a basis, and to determine how many cases in each quintile of the psychological test fall into the same quintile of the English test. Table III shows this agreement in each quintile and also in each category of the average grade points within the quintile. Thus, of the sixty-seven students in the first quintile of the psychological test who made less than a one-grade-point average, forty-six, or 69 per

[6] The present grade-point system of the State College of Washington was used: A, three points; B, two points; C, one point; K and F, no points.

TABLE II

Distribution based on percentile scores in Thurstone test.
"No." (in the left-hand column for each quintile) represents number of cases.

| Average Grade Points | 1-20% | | 21-40% | | 41-60% | | 61-80% | | 81-100% | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % | No. | % |
| 0- .99 | 67 | 54 | 42 | 33 | 28 | 25 | 20 | 17 | 10 | 8 |
| 1-1.99 | 55 | 45 | 85 | 65 | 79 | 70 | 80 | 69 | 69 | 58 |
| 2-2.99 | 1 | 1— | 2 | 2— | 6 | 5 | 16 | 14 | 40 | 34 |
| Total | 123 | 20 | 129 | 21 | 113 | 19 | 116 | 19 | 119 | 20 |

cent, are also in the first quintile in the English classification test. Fifty-five cases did satisfactory work, and the agreement is thirty-four, or 62 per cent. The very highest percentage of agreement is in the fifth quintile among the cases doing superior work, being thirty-four out of forty, or 85 per cent. The agreement between the two tests is higher in the first quintile and the fifth quintile, or at the extremes, than in the other three quintiles: 65 per cent in the first and 66 per cent in the fifth. In the whole group of 600 students, the agreement is 264, or 44 per cent.

The agreement as indicated in the Table III does not give a complete picture. Frequently a student's score would fall near the dividing line between two quintiles in one test and just on the other side of the dividing line in the other test, so that, although in different quintiles, the scores of the two tests would really be in very close agreement. Furthermore, of the sixty-seven students in the first quintile of the psychological test who earned less than a one-point grade average, forty-six were in the same division (the first quintile) in the English

TABLE III

Extent of agreement in distribution with the Thurstone test used as a basis for comparison

T represents the total number of cases in psychological distribution.

A represents the number of cases of agreement between the Thurstone test and the English test.

%A represents the percentage of the total psychological-test distribution in each division that agreed with the English-test distribution.

| Average Grade Points | 1-20% | | | 21-40% | | | 41-60% | | | 61-80% | | | 81-100% | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | T | A | %A | T | A | %A | T | A | %A | T | A | %A | T | A | %A | T | A | %A |
| 0- .99 | 67 | 46 | 69 | 42 | 9 | 21 | 28 | 8 | 29 | 20 | 8 | 40 | 10 | 3 | 30 | 167 | 74 | 44 |
| 1-1.99 | 55 | 34 | 62 | 85 | 24 | 28 | 79 | 20 | 25 | 80 | 30 | 35 | 69 | 41 | 59 | 368 | 149 | 40 |
| 2-2.99 | 1 | 0 | 0 | 2 | 1 | 50 | 6 | 3 | 50 | 16 | 3 | 19 | 40 | 34 | 85 | 65 | 41 | 63 |
| Total | 123 | 80 | 65 | 129 | 34 | 26 | 113 | 31 | 27 | 116 | 41 | 35 | 119 | 78 | 66 | 600 | 264 | 44 |

test, and seventeen of the remaining twenty-one were in the second quintile in the English test, or only one step from agreement.

The question has been asked a number of times: Why give the Thurstone test and the English classification test as well, inasmuch as the correlation between these two tests is so high? The question might well be asked at this point. The English test could hardly be discontinued, for it has proved to be very satisfactory for the purpose of sectioning students in both English composition and literature. It appears to be a better test for such classification than the psychological test. In an unpublished study, it was found that if students were sectioned in English courses according to the psychological test, there were more transfers to be made after the students had started their work than if they were sectioned according to the English test.

Likewise, it seems inadvisable to dispense with the Thurstone test. In the first place, school superintendents who are familiar with this psychological examination for entering freshmen frequently inquire about the ratings of prospective teachers in the tests. In the second place, a number of large corporations doing a nation-wide business ask for the ratings in mental alertness test scores when such ratings are available. The Thurstone test is rather widely known and seems to serve this purpose very well. Perhaps a more important reason why both tests should be used is the fact that a number of test results are better for guidance purposes than the result of only one test. The Thurstone test is used by such a large number of colleges that for comparative purposes alone it would be unwise to discontinue it.

# A POSSIBLE SOURCE OF LESSING'S *HOROSKOP*

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It has long been recognized that Lessing's unfinished tragedy *Das Horoskop* is a sort of modernization of the patricide theme in Sophocles' *Oedipus,* and that the horoscope was derived from a Pseudo-Quintilian *Declamatio major* (No. 4). This horoscope contains the germ of Lessing's plot: a father, just before the birth of his son, receives from the astrologers a horoscope which predicts that the child will grow up to be a brave man but afterwards will become a patricide. Furthermore, it has been pointed out that the Polish setting may have been suggested by Calderon's *Life Is a Dream* (which also has a horoscope and which Lessing had partially translated in 1750), and that the names *Peter Opalinski, Lucas Opalinski,* and *Massalski* were prominent in Polish history.[1] Erich Schmidt adds:

> Die geschichtlichen oder novellistischen Quellen Lessings sind unbekannt. . . . Frei über die Geschichte schaltend, hat Lessing seine, wer weiss wie geflochtene, vielleicht aus ganz anderem Boden erst nach Polen verlegte Handlung mit ihrem römischen Astrologenspruch im dämmerhafteren Beginn des fünfzehnten Jahrhunderts angesiedelt.[2]

A possible source of the love element in *Das Horoskop* is John Dryden's *Aureng-Zebe* (1676). The following parallelisms between the two works are not in the above-mentioned sources:

| *Aureng-Zebe* | *Das Horoskop* |
|---|---|
| The Old Emperor and his son, Aureng-Zebe, both love Indamora, a "captive queen" at the Emperor's court. | "Sobald Petrus die Massalska [a Polish lady who, after having not unwillingly followed a Tartar, had been captured by Petrus] sahe, ward er sterblich in sie verliebt, welche Liebe er in jedem Blicke, den er auf sie warf, verriet. Auch auf den Lukas [the son of Petrus] hatte Massalska Eindruck gemacht, und er wünschte sehr, dass ihm diese Beute geworden wäre."[3] |

[1] For a good presentation of the current knowledge concerning the sources of *Das Horoskop,* see Erich Schmidt, *Lessing: Geschichte seines Lebens und seiner Schriften,* 4th ed., ed. by Franz Schultz (Berlin, 1923), I, 342-44.

[2] *Op. cit.,* I, 343-44.

[3] The passages from *Das Horoskop* are quoted from *Lessings Werke,* ed. by Julius Petersen, Waldemar v. Olshausen, et al. (Berlin, etc., n. d.), X (ed. by Waldemar Oehlke), 197.

| | |
|---|---|
| Two other men, Arimant and Morat, also love Indamora. | Another man, Zuzi, also loves Anna Massalska. |
| The Empress is jealous of Indamora as a rival. | "Indes hatte Peters Gemahlin und Lukas' Mutter, Marina Opalinska, wohl bemerkt, welchen Eindruck Anna auf Petern gemacht habe. . . . Sie fürchtete, sein ganzes Herz darüber zu verlieren." |
| The Emperor resigns Indamora to his son. | ". . ., ob er [Petrus] schon nichts anders dabei [his intention concerning Anna] dachte, als wie er sie seinem Sohne zufreien möge." |

One might add that in *Das Horoskop*, as in *Aureng-Zebe,* the son seems to be a greater warrior than the father.

*Das Horoskop,* which is undated, is commonly assigned to about 1758.[4] External evidence indicates that at that time Lessing almost certainly was familiar with *Aureng-Zebe.* In a letter to Moses Mendelssohn December 18, 1756, Lessing had asked for the volume of Cibber's *The Lives of the Poets of Great Britain and Ireland*[5] containing the biography of Dryden,[6] inasmuch as he was preparing an article on the English playwright for the *Theatralische Bibliothek* (1754-58). *The Lives* gives a list of twenty-seven of Dryden's plays with a few words of comment on each, and concerning *Aureng-Zebe* the following passage appears: "Aureng-zebe; or the Great Mogul, a Tragedy, dedicated to the earl of Mulgrave, acted 1676. The story is related at large in Taverner's voyages to the Indies, vol. i. part 2. This play is written in heroic verse."[7] In the "Geschichte der englischen Schaubühne" (1758), he inserted: "Johann Dryden. Von diesem und seinen sämmtlichen dramatischen Werken werde ich in dem folgenden XIIIten Artikel umständlich zu handeln anfangen."[8] In the thirteenth article—entitled "Von Johann Dryden und dessen dramatischen Werken" (1758)—he published an abridged translation of Dryden's *Essay of Dramatic Poesie,* intending to discuss the plays in a subsequent article. Accordingly, we may practically take for granted that Lessing was acquainted

[4] Schmidt, *op. cit.,* I, 344-45.
[5] London, 1753 (5 vols.), III, 64-94.
[6] Lachmann-Muncker, XVII, 86. "Lachmann-Muncker" is used in this paper to designate the following edition of Lessing's works: *Gotthold Ephraim Lessings sämmtliche Schriften,* originally ed. by Karl Lachmann, 3rd (rev.) ed. by Franz Muncker (Stuttgart, etc., 1888ff.).
[7] III, 89.
[8] Lachmann-Muncker, VI, 249, n. 1.

with at least Dryden's more important dramas, among which is *Aureng-Zebe.* In 1763 Lessing spoke of ordering a copy of Dryden directly from England,[9] in 1767 he praised Dryden's epilogs[10] and included him in a list of six representative English writers of blank verse tragedies,[11] and in 1776 he sent a copy of Dryden to J. J. Eschenberg.[12]

Perhaps Lessing hit upon the idea of combining a horoscope theme with material from a Dryden play as a result of the fact that the biography of Dryden in Cibber relates that Dryden himself worked out a horoscope for his son Charles, although the content is different. "If he lives to arrive at his 8th year," the father is said to have told the child's mother, "he will go near to die a violent death on his very birth-day, but if he should escape, as I see but small hopes, he will in the 23d year be under the very same evil direction, and if he should escape that also, the 33d or 34th year is, I fear—" According to the account, the father had to break off here because of "the immoderate grief of his lady," but the prediction was fulfilled. Charles Dryden was buried under a wall in his eighth year, fell from a tower in his twenty-third year, and finally died in his thirty-third year through drowning.[13] As I pointed out elsewhere, Lessing utilized Cibber's *Lives* in 1759 for his fragment *Fatime.*[14]

[9] *Ibid.*, XVII, 194.
[10] *Ibid.*, IX, 213.
[11] *Ibid.*, IX, 247.
[12] *Ibid.*, XVIII, 216.
[13] III, 80-82.
[14] "The Authorship of 'Die Englische Schaubühne,'" *Research Studies of the State College of Washington,* III (1935), 63-66.

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# STATE COLLEGE OF WASHINGTON



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# RESEARCH STUDIES

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# RESEARCH STUDIES of the STATE COLLEGE OF WASHINGTON

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# PIONEER SOCIAL ADAPTATION IN THE PALOUSE COUNTRY OF EASTERN WASHINGTON, 1870-90

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## NEGLECT OF FRONTIER RURAL SOCIOLOGY

A group of American historians for more than a generation have pointed out the influence of frontier conditions on the ways of living and thinking of that part of the population constituting the westward-moving frontier in our national history; and they have discussed the repercussions of these frontier ways of living and thinking on the economic, social, and political institutions of the country.[1] A rich fictional literature has also grown up portraying frontier social life.[2] American rural sociologists, however, have given little attention to the influence of frontier conditions on the social life and institutions that they have analyzed in the standard texts in this field.[3] Only a few of the books in the rapidly growing literature in rural sociology have

[1] See F. J. Turner, *The Frontier in American History* (New York, 1920); F. L. Paxson, *History of the American Frontier, 1763-1893* (Boston, 1924); Emerson Hough, *The Passing of the Frontier* (New Haven, 1920); J. D. Hicks, *The Populist Revolt* (Minneapolis, 1931); D. E. Clark, *The West in American History* (New York, 1937); W. P. Webb, *Divided We Stand* (New York, 1937); and C. L. Becker, *The United States: An Experiment in Democracy* (New York, 1920). For criticisms of the frontier thesis see: Carter Goodrich and Sol. Davidson, "The Wage Earner in the Western Movement," *Political Science Quarterly*, L (1935), pp. 161-81; LI (1936), pp. 61-116; Fred A. Shannon, "The Homestead Act and the Labor Surplus," *American Historical Review*, XLI (1936), pp. 637-51; Joseph Schafer, "Was the West a Safety Valve for Labor?" *Mississippi Valley Historical Review*, XXIV (1937), pp. 299-314.

[2] See the list of novels on frontier life cited in an article by Caroline B. Sherman, "Rural Fiction as Interpreter of Rural Life," *Rural Sociology*, II (1937), pp. 36-47; also many novels on frontier life included in the very comprehensive bibliography by Anna M. Clark, *A Key to Sectional Cultures through Their Literature* (in manuscript), Young Women's Christian Association, New York.

[3] See such texts as J. L. Gillette, *Rural Sociology*, 3rd Ed. (New York, 1936); C. C. Taylor, *Rural Sociology*, Rev. Ed. (New York, 1933); P. Sorokin and C. C. Zimmerman, *Principles of Rural-Urban Sociology* (New York, 1929); N. L. Sims, *Elements of Rural Sociology*, Rev. Ed. (New York, 1934); C. R. Hoffer, *Introduction to Rural Sociology*, Rev. Ed. (New York, 1934); J. H. Kolb and E. de S. Brunner, *A Study of Rural Society* (Boston, 1935).

given much more than passing notice to the effects of the frontier on rural social life.[4] The rural sociologists of the United States now probably have a larger and more nearly scientific body of monographic literature to draw from in their general writings than has any other branch of sociologists—chiefly because of the availability of Federal government funds for research.[5] But little or none of this literature is historical in character. It deals with current rural social conditions, and its treatment of the historical development of rural social life is only incidental. A few years ago a most valuable series of monographs on methods of research and investigation in rural sociology was prepared by a group of rural sociologists under the auspices of the Social Science Research Council, but no monograph on methods of historical study of rural social life was contained in the series.[6]

Within the last few years, however, studies making a sociological analysis of rural life under frontier conditions have begun to appear.[7] Study and research into rural pioneer social life remains a rich field of exploitation for rural sociologists. In areas where frontier conditions have long since passed, studies of this kind must necessarily be based on such records as newspapers, letters, diaries, and deeds. But in the far Western states, where many of the original pioneers in rural communities are still living, the carefully planned personal interview is an important source of information on frontier social life. The writer believes that rural sociologists in the far Western states can most profitably further historical research in rural sociology by personal-interview studies among those pioneers still living in these rapidly disappearing frontier communities.

[4] Books in the field of rural sociology giving some emphasis to the influence of the frontier on rural social life are J. M. Williams, *Our Rural Heritage* (New York, 1925) and *The Expansion of Rural Life* (New York, 1926), and Warren H. Wilson, *The Evolution of the Country Community*, Rev. Ed. (Boston, 1923).

[5] See bibliography, *Publications Relating to Farm Population and Rural Life* (mimeographed), Division of Farm Population and Rural Life, U. S. Department of Agriculture (1936), and lists of publications since 1936 in issues of *Farm Population and Rural Life Activities*, U. S. Department of Agriculture.

[6] The series contains monographs on research in *Rural Population, Farm Family Living, Rural Organization, Farm Labor, Social Psychology in Rural Life, Rural Institutions,* and *Rural Social Work.*

[7] See John Ise, *Sod and Stubble: the Story of a Kansas Homestead* (New York, 1938); Everett Dick, *The Sod-House Frontier, 1854-90* (New York, 1937); R. W. Murchie, William Allen, and J. F. Booth, *Agricultural Progress on the Prairie Frontier* (Toronto, 1936); W. A. MacIntosh, A. B. Clark, G. A. Elliott, and W. W. Swanson, *Economic Problems of the Prairie Provinces* (Toronto, 1935); and A. R. M. Lower, *Settlement and the Forest Frontier in Eastern Canada* (Toronto, 1936).

This article is based on personal interviews with fifty pioneer men and women living in all parts of the Palouse Country of eastern Washington. The interviews were made in 1936, 1937, and 1938. The pioneers interviewed came to the Palouse Country between 1870 and 1890. A systematic, uniform outline was used in all the interviews, covering the phases of rural social life generally treated by the rural sociologists.[8] Full typed copies of the interviews have been placed in the Northwest historical collection of the Library of the State College of Washington.[9]

PIONEER LIFE AS SOCIAL ADAPTATION

The most essential characteristic of social life on the frontier seems to the author to be an adaptation of the general economic and social culture of the incoming pioneers to the natural and limited technical conditions of the new area in process of settlement. Several American sociologists have suggested that a study of such adaptation is the most desirable approach to the sociological analysis of frontier communities.[10] One sociologist has defined a frontier as "that region on the outer fringe of settlement where pioneers are forced, for the sake of survival, to make new adjustments to a raw environment. It is a region, it is a process, it is even a state of mind." [11] Settlers migrating from old, well-established communities to new frontier communities find themselves in possession of mental cultural patterns more or less adequate for economic and social living, learned in the old communities, but limited in the application of these patterns by the conditions imposed by the frontier situation. Consequently, there follows in

[8] Major points of inquiry were: Reasons for Coming, Experiences of the Journey, Getting the Land, Housing, Food and Provision, Types of Farming, Farm Work, Transportation, Markets and Trading, Credit, Health and Medical Facilities, Neighborliness, Church and Sunday School, Schooling, Mail and Newspapers, and Protection.

[9] Fred R. Yoder, *Stories of Early Pioneers in Whitman County* (1938), typed manuscript, State College of Washington Library, Pullman, Washington. Persons at whose homes calls were made were: Thomas Neil, George Reed, Irwin Lewis, Pullman; Sarah J. Wohleter, Emma Ickes, J. D. Kincaid, C. H. Farnsworth, Palouse; S. D. Mustard, Frank Mraz, Michael Schulteis, Colton; Levi Wiggins, Johnson; J. D. Butler, C. Y. Edwards, Pine City; Clara McQueen, G. W. Easter, Armanda J. Harlow, Farmington; James Benson, James McCroskey, St. John; Sanford Moore, L. S. Warner, Endicott; Charles Ketchum, Malden; G. A. Draper, Elberton; Molly Short, Albion; M. B. Darden, Edward Carmen, La Crosse; Hans Mumm, Rosalia; A. B. Willard, George Engeland, Tekoa; R. W. Ferris, Dusty; S. G. Leach, Garfield. Usually both pioneer husband and wife helped give the information, and sometimes children of pioneers also helped.

[10] See A. G. Keller, *Societal Evolution*, Rev. Ed. (New York, 1931), Ch. X; and J. G. Leyburn, *Frontier Folkways* (New Haven, 1935).

[11] J. G. Leyburn, *op. cit.*, p. 1.

the frontier community a period of struggle, adjustment, and adaptation to the new conditions.[12] If the frontier region is still inhabited by people of a more primitive culture, but a culture adapted to the natural and technical conditions of the region, the incoming pioneers may adopt or borrow certain phases of the primitive culture for a short period of time. Thus there appears to be a retrogression in the culture of the pioneers. But on closer sociological analysis this borrowing of the more primitive culture is seen to be a wise and useful adaptation to the exigencies at hand.[13]

In the opinion of the author, the adjustments made by pioneers in the new frontier community are basically determined by material and economic conditions.[14] A student of the sociology of frontiers has said that "man's most sensitive nerves seem to run to his stomach and to his pocket-book," [15] which is to say that the material and economic conditions of life receive prime consideration among most people, whether inhabitants of old or new communities. The pioneers were usually people of little wealth. Their movement to the new frontier communities was chiefly for the purpose of bettering their material and economic status.[16] It is not denied, however, by the author of this article that familial, religious, moral, recreational, educational, and political factors are significant in shaping the general social life of communities. These factors interact with the material and economic factors. But the view is held by the author that the primary interest of most people is their material and economic circumstances, that the material and economic life and institutions become the basic patterns of the community, and that the other phases of social life adapt themselves to the material and economic patterns. Although there is still considerable difference of opinion among American sociologists as to the role of material and economic factors in the general social life,[17] the author believes that recent developments in the farm life of the United States during the last decade has shown the outstanding significance of the material and economic factors.[18]

[12] See A. G. Keller, *op. cit.*, pp. 351-65.
[13] *Ibid.*
[14] This is the view held by Keller and Leyburn in the works already cited.
[15] J. G. Leyburn, *op. cit.*, p. 236.
[16] This fact is brought out by the various books on the frontier which have been cited above.
[17] See P. A. Sorokin, *Contemporary Sociological Theories* (New York, 1928), Ch. X, for a critical evaluation of the theories of the economic sociologists.
[18] See accounts of New Deal Legislation in behalf of depressed agriculture in L. M. Hacker, *American Problems of Today* (New York, 1938), pp. 207-17;

THE PALOUSE COUNTRY

The Palouse Country of eastern Washington lies very largely in Whitman County, which is a very large county, about sixty miles long, north and south, and about fifty miles wide, east and west. The Palouse Country is essentially the area drained by the Palouse River and its tributaries. Though there has been much speculation as to how the country got the name "Palouse" the best evidence is that the name comes from the tribe of Indians who inhabited the area and who called themselves the Palouse tribe.[19]

The Palouse Country is an extensive plateau with an elevation around 2500 feet above sea level. It is cut by a number of small river and creek valleys. Topographically the area has been described as one "of choppy relief, with many steep short slopes."[20] The area includes very little level land, though almost all of it is farmed today by tractors, gang plows, and large harvesting combines. The soil is volcanic in origin and is the product of the disintegration of basaltic rock. Though the soil is underlaid with a deep bed of dark brown clay, the top soil is a deep, rich, dark loam, which has been pulverized and refined by thousands of years of freezing and the annual decadence of a luxurious growth of bunch grass. When the settlers came into the area in the 'seventies and 'eighties it was covered with bunch grass that grew two to four feet high. The only timber was a few pines, willows, and cottonwoods along the streams, and small brush in low draws. The annual rainfall ranges from twelve inches in the western part of the area to twenty-one in the eastern part. Despite the low rainfall, the country is well watered. There are springs and small streams on almost every section of land. Good well-water is reached at depths ranging from ten to fifty feet. The temperature is mild and relatively even throughout the year. Though there is generally some sub-zero weather in the heart of winter, the winters for the most part are not severe. The summers are rarely hot and even during hot weather the nights are almost always cool. The summers are dry, for there usually is little or no rainfall from the middle of June till the middle of September.

and Fred R. Yoder, *Introduction to Agricultural Economics*, Reprint (New York, 1938), Appendix B, pp. 473-85.

[19] See C. C. Todd, "Origin and Meaning of the Geographic Name Palouse," *Washington Historical Quarterly*, XXIV (1933), pp. 190-92.

[20] W. A. Rockie and P. C. McGrew, "Erosion Effects of Heavy Summer Rains in Southeastern Washington," Washington State Agricultural Experiment Station Bulletin No. 271, p. 3.

HISTORY OF THE PALOUSE COUNTRY

The Palouse Country began to be traversed frequently by white men in the 'sixties, when gold was discovered in the hilly and mountainous areas to the north and east.[21] This discovery of gold and the working of the placer mines attracted many persons who travelled over the area and reported to the outside world its virgin agricultural and pastoral possibilities. A few missionaries were in the country during the 'sixties.[22] The Indian tribes to the east, north, and west, however, travelled over the country frequently and extensively on their way to and from their fishing places on the Columbia, Snake, and Clearwater Rivers, and on their annual journeys to pick huckleberries in the nearby hills and to dig the camas root in the elevated prairies to the north and the south.[23] Although the great stream of "Oregon country" immigrants increased yearly from 1840 to 1870, these immigrants remained south of the Snake River and passed on to the Willamette Valley and to the Puget Sound country, chiefly because the inland Indians of the upper Columbia, Snake, and Clearwater rivers were still war-like, were not confined to reservations, and were a constant threat to any white settlers who came north of the Snake River.[24] Not until after the Indian wars of 1855 and 1857, and the decisive defeat of the Indians and the killing of their ponies by United States cavalry troops was it safe for settlers to enter the Palouse Country.[25]

The Walla Walla country and all the Prairie country south of the Snake River was rapidly occupied after the country had been thrown open for settlement in 1858.[26] Many of the settlers in this area were stockmen, grazing their cattle, sheep, and horses somewhat like nomadic herdsmen.[27] In the 'sixties some of these stockmen began to cross the Snake River with their herds and graze them on the nutritious bunch grass of the Palouse hills and valleys.[28] In the period of 1859-62 a military road was built between Walla Walla and Fort Benton in

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[21] W. H. Lever, *History of Whitman County* (published privately, 1901), p. 99.

[22] *Ibid.*, p. 98; and G. W. Fuller, *History of the Pacific Northwest* (Portland, Ore., 1931), pp. 139-42.

[23] These travels of the Indians still continued long after white settlement of the Palouse Country.

[24] W. H. Lever, *op. cit.*, pp. 82-92.

[25] *Ibid.*, p. 98.

[26] F. T. Gilbert, *Historic Sketches of Walla Walla, Whitman, Columbia, and Garfield Counties* (Portland, 1882), Chs. XXVII, XXXVI, and XXXVIII.

[27] W. H. Lever, *op. cit.*, p. 104; and F. T. Gilbert, *op. cit.*, pp. 294-95.

[28] W. H. Lever, *op. cit.*, p. 102.

Montana, which traversed the Palouse Country.[29] By 1861 small steamboats were operating up the Snake River to the junction of the Snake and Clearwater Rivers, carrying mining supplies for the placer-mining regions north and east of the Palouse Country.[30] During the early 'seventies, stages began to operate north and south across the Palouse Country.[31] By 1870 the Palouse Country was accessible by steamboat, wagon road, packtrain, and stage. Then during the early 'seventies the settlers began to pour in, and in the short space of fifteen years practically all the land had been taken up by settlers.[32]

### THE PULL OF THE LAND[33]

Land hunger was the chief motive bringing most of the settlers to the Palouse Country. The old settlers even after fifty and sixty years in the Palouse Country had ready answers when asked why they left their more comfortable homes and well-established communities in the Middle Western and Eastern states to take up life in the distant Palouse Country: "Father had heard and read glowing accounts about the fertile prairies of eastern Washington." "Father wanted to find land for all of his boys." "We found all the good land taken up in the Willamette Valley and we heard there was still plenty of good land in the Palouse Country." "On the boat from San Francisco to Portland we heard about the fine land in the Palouse Country." "We were driven out of Kansas by the grasshoppers and were looking for a better farming country." "Father was a stockman and wanted to go where there was still plenty of good land." "Father was the type of man who wanted to be far out on the frontier." "Father heard of the great stretch of open prairie country in eastern Washington." "Father wanted a piece of good prairie land for each boy." "We heard of the untouched Indian prairies." So run the replies of the old settlers from the older states as to why they or their families came to the Palouse Country. Two pioneers from Germany said they left their native land and came to the United States and to the Palouse Country because they wanted to own land and farm permanently but feared that the

[29] G. W. Fuller, *op. cit.*, 316-17.
[30] W. H. Lever, *op. cit.*, pp. 169-70.
[31] *Ibid.*
[32] One old settler related that his family arrived in a community near Palouse City in 1877 in which only a few homesteads had been entered, and that "in three years every acre of land had been entered."
[33] The source of information for the major points in the rest of this article is the author's manuscript, *Stories of Early Pioneers in Whitman County* (see above, footnote 9).

rising tide of Socialism in Germany in the 'seventies threatened the very existence of private land ownership. The rich, fertile Palouse Country was a veritable magnet for the land-hungry settlers. With its settlement in the 'seventies and 'eighties one of the last phases of the epic drama of the American covered wagon came to an end.

### EXPERIENCES OF THE WESTWARD JOURNEY

The long journey from their Eastern and Middle Western homes to the Palouse Country still remains vivid in the minds of most of the pioneers. This journey itself was an adaptive process to modes of travel, besetting dangers, and limited economic means. Most of the settlers who came to the Northwest in the 'sixties and very early 'seventies came by covered wagon trains, which were organized communities on the march and were often guarded and guided by United States troops through those sections of the great plains and the Rocky Mountain country inhabited by hostile Indians. Many of the oldest settlers related stories of cautious movement of the wagon trains through the Indian country, the arming of all men, the sending of scouts ahead and the posting of guards at night, the circled formation of the wagons at night for protection, the wearing down and loss of teams, and the occasional loss of loved ones from Indian attacks and from death on the long journey. Some of the settlers made the journey to the Palouse Country by three different methods of travel: wagon, railroad-immigrant train, and steamboat.

An interesting experience to a number of the settlers was the travel by immigrant train. In May, 1869, the first transcontinental railroad was completed by the joining of the westward-extending Union Pacific and the eastward-extending Central Pacific at a point in Utah.[34] This joining of the two railroads, connecting with ocean and river steamship lines, made available for settlers who could afford it a continuous journey by railroad and steamboat from the Middle West to the Palouse Country by way of railroad to San Francisco, ocean-going vessels from San Francisco to Portland, and small river-going boats up the Columbia and Snake Rivers to the lower edge of the Palouse Country.[35] The immigrant trains were mixed freight and passenger trains. The settlers and their families living in the Middle West

[34] John Moody, *The Railroad Builders* (New Haven, 1919), Ch. VI.

[35] A number of settlers stopped in California and Oregon for a year or two before coming to the Palouse Country.

loaded their wagons and their livestock into freight cars and themselves into passenger cars, and journeyed to San Francisco. The families cooked and served their meals on the train. At frequent intervals the train stopped to allow the settlers to go back to the stock cars to feed and water their horses and cattle. At San Francisco the settlers took boat for Portland, and on arrival there reshipped on smaller boats for the Palouse Country. Travel by immigrant train, though infinitely superior to travel by covered wagon, was slow as compared with travel by regular passenger train. A good rate of speed for the immigrant train was 250 miles a day. The pioneers had to adjust themselves to modes of travel at hand.

Fear of the Indians was uppermost in the minds of the settlers who made the long journey to the Palouse Country in the early 'seventies by covered wagon. Though very few of them experienced attacks by Indians, they heard many stories and rumors all the way along the journey about fierce Indian tribes ready to swoop down on them at different laps in the journey. Several settlers told how they walked or rode with loaded guns in their hands all the way across the plains and through the Rocky Mountains, till they arrived at their destination in the Palouse Country. It was in part conditioned by the Indian massacre stories heard during the two-thousand-mile journey through the plains and Rocky Mountain Indian country.

A common experience of the Palouse pioneer was to come to a nearby settlement like the Willamette Valley, Walla Walla, or Dayton, leave his family in camp or with an old neighbor who had preceded him to the Northwest, and make a reconnoitering journey into the Palouse Country, locate a piece of land which he wished to homestead or buy, and then return to bring his family.

The remoteness of the Palouse Country was impressed on some of the pioneers when they arrived at San Francisco and tried to reship their household goods. "Palouse City," "Colfax," "Farmington," and other Palouse Country points of destination were not listed in the freight books. Nor did these places appear on the maps. The difficulty was several times solved by an agreement of the resourceful freight agent and the pioneer to take a chance on shipping the goods to "Lewiston, Idaho, Junction of the Clearwater and Snake Rivers." More disheartening to the pioneers pushing on toward the Palouse Country were the stories of occasional caravans of settlers whom they met in Portland, the Willamette Valley, and the Walla Walla country—people

who had been "up there," had found the country "unlivable," and were "returning to civilization." "That wild country is no place to take women and children"; "Indians are still roaming around on their trails"; "it is a cold, frosty country where you can't grow much of anything"; "you won't have any neighbors up there"; "the land is nothing but hills"; "the only level land is in the meadows and they are all taken up"; "nobody can grow crops on such hills"; and so the stories ran, making the weary pioneer and his family wonder whether they had made an expensive and foolish journey to the "rainbow's end," which they could not retrace. A number of the old pioneers said that it took courage to finish the journey after their families had heard these stories.

### ADJUSTMENT TO THE LAND

When the first settlers arrived in the Palouse Country in the early 'seventies, the land was just being surveyed. Stockmen had been grazing a part of the country along the Snake River before it was surveyed. The earliest settlers homesteaded. It was common for a young, single man to homestead a section of good land, build a shack on it, live on it long enough to gain title, and then sell out to a permanent settler and move on to another area. Many of the permanent settlers bought relinquishments, squatters' rights, and preemption claims, and moved their families into crude shacks built by the original homesteaders. The land for sale could be bought for from one to two dollars an acre in the early 'seventies. With a capital outlay of a few hundred dollars a settler could begin farming.

The early settlers had some difficulties at first in adapting their ideas and farming practices to the type of land found in the Palouse Country. Most of them coming from the Middle West were looking for flats, meadows, and partly timbered land. The Palouse hills looked too steep for farming. Many of the settlers thought the hills would be good only for grazing. One old settler related to the writer how he got on a horse and rode for days and days over thousands of acres looking for land which was level enough to grow wheat—passing up thousands of acres of hilly land that has for the last sixty years been growing forty, fifty, and even sixty bushels to the acre every other year.[36] The settlers spent a decade in experimenting in the use of the land and

[36] A fallowing system of allowing the farm land to lie idle every other year is followed in the Palouse Country.

adapting their farm practices to soil, topography, rainfall, and seasons. The frost-free seasons seemed unduly short. Gardens and fruits were killed. Wheat was frost-bitten. The settlers had to learn that early gardens could not safely be planted in low flats, because of frosts, and that north hillsides contained plenty of moisture to make good gardens in summers without rains. After a decade of experimentation it was found that the Palouse hills would grow good wheat right to their tops. In another decade it was found that heavy farm machinery could be operated on the steep hillsides, and several farm machinery companies began to manufacture special types of machines for use in the hilly Palouse Country.

Settlers at first avoided the western part of the Palouse Country that had only twelve to fifteen inches of rainfall, believing that part of the country was too dry for successful farming. Settlers were advised not to get over twenty miles west of the Idaho line if they wanted to grow good crops. In the late 'seventies and early 'eighties, after wheat became the great money crop, bankers and money lenders financing wheat growers would not make advance loans to farmers growing wheat west of a line running north and south through the middle of the Palouse Country. But as the better eastern lands were taken up, the late-comers in the 'eighties were forced to seek homesteads in the western area of less rainfall. These settlers at first engaged in raising horses, cattle, and sheep. But little by little these farmers experimented with growing wheat, at first trying out a few acres in the most favored spots. They soon found wheat culture quite successful and turned to it as their major farming activity. Without agricultural experts or a college experiment station to advise them, the Palouse settlers in two decades made their major adjustments to the land.

## HOUSING

With his claim staked out or his land purchased, the most immediate and pressing problem of the pioneer was to provide shelter for his family. Many a family camped in a tent for several weeks or even months, while logs or lumber were being brought in to build a cabin. The settlers had to adjust their early housing to the great timber scarcity. Lumber and logs had to be brought from considerable distances—often fifteen and twenty miles. A few pioneers reported that their first houses were caves dug out in the hillsides with shelters erected over them.

Little sawmills were built along the streams, and logs were cut from the north hillside slopes. The demand for lumber usually exceeded the supply at the mills. Sometimes a dozen men would wait at one of the little mills a whole day and each would take his turn in getting boards. After a whole day's waiting, a settler might return home with a half dozen boards. One pioneer told of waiting a whole day and getting only three boards.

The most common type of house erected in the early days was the small box-house, usually twelve by fourteen, or fourteen by sixteen, or sixteen by twenty—sometimes having a "lean-to" on one side. Strips were nailed over the cracks between boards. During the very cold weather the cracks were stuffed with paper or rags to keep out some of the cold. Where log houses were built, it was sometimes hard to get boards for floors. One pioneer reported living in a log cabin two and a half years before he was able to buy boards for a floor. Many of the cabins were built without any windows.

If the first houses and cabins were crude, furnishings were still cruder. For a number of years no furniture could be bought in the Palouse Country, and there were few furniture makers. A number of settlers told of racks or frames built on the side of the walls for beds. Nail kegs and sugar barrels were used for chairs in some homes. The same crude stoves were often used both for cooking and heating the house. Candles were first used for lighting. In the 'eighties kerosene began to be shipped in and the kerosene lamp was used.

## FOOD AND PROVISIONS

Settlers arriving in the Palouse Country usually brought a fair supply of food with them. It was the common practice to stock up with a supply of provisions at Walla Walla. Some of the established settlers living on the road between Walla Walla and the Palouse Country were very generous and hospitable in helping the new immigrants stock up with vegetables, fruits, and bacon, which they knew were scarcely available north of the Snake River. In the earliest days certain kinds of food became very scarce in some families, and new supplies were found only with great difficulty. One old settler living on the northern rim of the Palouse Country remarked that his family ran out of meat and that he rode for two days, going from house to house trying to purchase a little meat, finally being able to buy two pounds of bacon about thirty miles from home. Another settler commented that his

family was without anything to eat for a whole winter except flour, and that all cooking had to be done without any kind of grease or shortening.

Flour mills were built on several of the streams in the country, and these mills were kept busy grinding the "turns" of wheat brought in by the settlers, who sometimes came considerable distances. After the settlers had been in the country a season there was no lack of flour, though several told of the "terribly sticky" flour they had as a result of frost-bitten wheat. It took several years for the settlers to learn what fruits and vegetables they could safely and effectively grow. A few of the settlers told how hungry their families became for fruit, which could not be purchased at any price in their vicinity.

In the early days the Palouse streams were full of fine trout, and many boys helped supply the table with fresh meat by a few hours of angling along the streams. Another natural source of food supply appreciated by many of the pioneer families was the fine huckleberries that grew on the north hillslopes of the streams, and in vastly larger quantities in the wooded hills and mountains to the east of the Palouse Country. It became a custom among many of the pioneer families in the early days to go in groups to the huckleberry forests and bring in large quantities for a part of the family fruit supply.

In the earliest days sugar was scarce and sometimes quite a luxury. In the late 'seventies sugar retailed in stores of the Palouse Country at twenty to twenty-five cents a pound. Sugar was so expensive in the local stores that some of the families planned annual shopping trips to Walla Walla chiefly for the purpose of buying sugar, which could be bought much cheaper there than in the Palouse stores.

## TYPES OF FARMING

After the settler was on his land, his first task was to adapt himself to such farming operations as would bring him the quickest and highest returns for the least expenditure of money and energy. During the first few years of settlement in the 'seventies, many of the settlers found horse and cattle raising the most profitable farming business. The luxuriant, nutritious bunch grass on the hills and in the meadows made the Palouse Country unexcelled for grazing horses and cattle. Stock could usually be left on the open range all winter without feeding or shelter. Many of the new settlers coming into the country arrived with their teams worn out or without any horses at all. This created a demand for young horses. Mining centers in Idaho, Montana, and

British Columbia furnished a good market for beef cattle, which were driven on foot in great herds to these mining regions.

It was necessary for the early pioneers to adjust their farming practices to market and transportation conditions. Just as soon as steamboats began to run regularly on the Snake River and carry wheat down the Snake and Columbia Rivers to Portland for the export market, the pioneers turned to extensive wheat-growing, for which the Palouse Country is ideally fitted. Breaking the heavy bunch grass sod was no easy task with the light twelve-inch plows which the settlers had brought with them from the Middle West or which were first offered for sale by village implement dealers. Several pioneers told how they turned droves of hogs into meadows with unusually stiff sod and let the hogs do the first breaking.

Wheat was first sown broadcast by hand, sometimes on foot and sometimes on horseback. Broadcasting was the only method used for a decade by some of the earliest settlers. In the first few years of settlement wheat was cut by cradle or scythe. So scarce were cradles in some communities that settlers borrowed them from neighbors and cut wheat all night by moonlight, and returned the cradles to their owners by work time the next morning. Wheat was threshed by flails or by having horses tramp it out. In one community near an Indian reservation some of the settlers hired Indians to come with their poines to tramp out the grain. Wheat-raising by hand labor for the most part was heavy work, but the settlers were required to adjust their farming practices to the natural and technical conditions of their new environment.

In the late 'seventies horse-power machinery for raising wheat began to become available. Dump reapers, headers, threshers, rakes, wire binders, gang plows, and drills began to be shipped up the Snake River to various landing points in the Palouse area. Then in the 'eighties the Palouse farmers began to adapt their farming operations to large-scale, horse-power machinery. Farms increased in size from an average of 203 acres per farm in 1880 to 286 acres in 1890.[37]

### FARM WORK

During early pioneer times in the Palouse Country there was a great deal of cooperation among settlers in their farm work. This

[37] E. A. Taylor and F. R. Yoder, "Rural Social Organization in Whitman County," Washington State Experiment Station, Bulletin No. 203, p.9.

group work was another adjustment to pioneer life conditions. Many of the families came to the Palouse Country together in small caravans, out of the necessity of group protection. They settled as neighbors on adjoining farms, ever ready to band together for further protection in the face of danger. They went together to nearby wooded mountains and timber spots to cut timber and get logs to build cabins. They helped one another build houses, barns, and fences, and cut and thresh wheat. They travelled together in caravans of dozens of wagons hauling their wheat to shipping points on the Snake River, and bringing in supplies from Walla Walla. Occasionally one settler who had some special skill like blacksmithing or carpentering would trade his work for the services of a settler with a team.

Old pioneers who were mere boys when they arrived in the Palouse Country in the 'seventies recalled vividly their work as farm boys. One of the most frequent experiences of farm boys was riding the unfenced ranges in order to herd the cattle and horses. One settler told how he, as a fourteen-year-old boy, with his slightly older brother, rode the ranges in the dead of winter, sleeping out under hides and blankets, away from home four to ten days at a time, trailing horses which had gone astray. Branding livestock was a sideline followed by a number of farm boys for the purpose of earning a few dollars. One old settler reported that he and his brother learned to round up all the cattle in a countryside by getting two bulls to fighting and bellowing, a disturbance which invariably brought all the cattle within a mile radius to the spot of the bull-ring. This cow-boy versatility in getting the range work done was another adjustment to the exigencies of the situation.

Boys and young men anxious to make a few dollars with which to get started in farming on their own or to get married found various ways of earning small sums of money. Some of them went south during the harvest season to the Walla Walla country, where hands were in demand and where they could get two or three months of work at good wages. Others went to the mountains and found employment at working in the timber. When the railroads began to be built into the Palouse Country in the 'eighties, a number of them made what seemed "lucrative" earnings working as construction hands on the railroads.

Not many of the pioneer women reported working in the fields, though a few of them said that they drove teams, harnessed and fed horses, and plowed and helped in the harvest. Almost all the pioneer

women told of the heavy cooking, in addition to regular household work, during the harvest season when many extra hands were required. The pioneer farm women, as much as the men, were friendly and cooperative neighbors and helped one another in many good "turns."

### TRANSPORTATION

The Palouse pioneers readily adapted their travel and hauling to the transportation facilities which were available. Across the country in various directions ran Indian trails, in some places half a dozen of them running abreast, and at places cut two and three feet in the ground. These trails had probably been in use hundreds of years by the Indians, first as foot-paths and later as both foot- and horse-paths, after the Indians had begun using horses. The early settlers found these Indian trails convenient for travel and used them extensively. Every member of the pioneer family learned to ride horseback at an early age and sometimes the whole family traveled to points on horseback. Where there were no Indian trails, the rider on horseback struck out in a bee-line across the prairies and hills. One settler related that his father stretched a cord through the tall bunch grass from the home cabin to a little schoolhouse a mile and a half away, so that the children by following the cord might not get lost going and coming from school.

From the very beginning of settlement Palouse settlers had an outlet to the south by boat and wagon road.[38] They had the advantage of the military road which had been constructed north and south across the country. In 1871 the Northwestern Stage Company began operating a system of stages that made connections with various points in the Palouse Country.[39]

In the first few years of their homesteading the settlers had no wagon roads and drove over the untrodden prairies to make connections with the few main constructed roads. In the winter when there were good snows, some of the settlers used bob-sleds for transportation, taking wheat to market and bringing back supplies over distances of thirty and forty miles. By the middle of the 'seventies the settlers were busy constructing roads, particularly down the canyons to shipping points on the Snake River. As these wagon roads to the Snake River landings were built, wheat-raising increased tremendously and, just after the harvest, caravans of hundreds of wagons hauled the wheat

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[38] W. H. Lever, *op. cit.*, p. 169.
[39] *Ibid.*, p. 170.

from all points in the Palouse Country to these shipping points. For a while it seemed that a number of important trading towns might grow up on the north bank of the Snake River. But in the middle 'eighties two railroad systems began to penetrate the Palouse Country. Soon branch lines were built through every section of the region. Many local warehouses were erected along the railroads for receiving the wheat. The settlers soon adjusted their marketing to the new railroad-transportation system. The little trading towns on the Snake River dwindled and practically disappeared.

### MARKETS AND TRADING

The Palouse pioneer had livestock and grain to sell, and he needed hardware, harness, farm machinery, clothing, furniture, and a few groceries. It was necessary for the settlers to adapt their buying and selling to the market facilities at hand. In the 'seventies cattle buyers roamed the Palouse Country, purchased any cattle the settlers had for sale, and drove them in large herds to the mining centers and even to Kansas City. There was a limited market for pork at the village stores. Some of the stores would take butter, eggs, poultry, and potatoes in exchange for goods that settlers wished to buy, but the prices allowed for them were always extremely low during the late 'seventies and early 'eighties.

By 1880 the Palouse settler was raising an average of three hundred bushels of wheat and seventy bushels of rye, most of which was marketed.[40] From 1875 to 1882 the settlers usually got from twenty-five to thirty cents a bushel for their wheat delivered at the Snake River landings. Later in the 'eighties they received forty and occasionally fifty cents a bushel. Much of the wheat was shipped to commission merchants in Portland in the earliest days before local buyers began to make purchases. Getting the wheat down to the Snake River landings was no easy task. From the more distant points in the Palouse Country the trip to the landings and back required four to six days. One pioneer pointed out a spot in a meadow by his house where as many as fifty and sixty teamsters with their wagons were often encamped in a single night, on their way to and from a landing on the river.

The earliest supplies for the Palouse settlers were generally purchased in Walla Walla, a distance of 60 to 150 miles from different

[0] *Statistics of Agriculture,* 10th Census (1880), p. 210.

parts of the Palouse Country. Caravans of settlers made annual trips to this trading center to lay in their supplies of goods. Some of the settlers continued to go to Walla Walla for their supplies for a decade, even though stores with supplies were available in the Palouse Country, chiefly because the merchants at Walla Walla discounted their "greenbacks" only five per cent, whereas the local Palouse merchants insisted on discounting them ten and fifteen per cent. The settlers also found a greater variety of goods at Walla Walla and lower prices.

By the middle 'seventies stores were in operation in half a dozen villages in the Palouse Country. Freight lines were operating from Walla Walla and Snake River landings to these village centers, in which were usually found implement stores, hardware stores, harness stores, general supply stores, drug stores, meat markets, wheat mills, and numerous handicraft shops, all ready to supply the settlers with goods and services. Lone country stores were established at many crossroads. By 1880, supply stores were available within a range of five or ten miles for every settler, except in the extreme western part of the country.

### CREDIT

Most frontiersmen are debtors. The great majority of the Palouse settlers found themselves "broke" by the time they had built their cabins. They had plenty of good land, but were without capital to begin their farming operations. There was a great demand for credit. The settlers had to adjust themselves to a set of frontier credit practices and institutions. Most of the oldest pioneers recalled how scarce money was when they got to the Palouse Country in the 'seventies and how high interest rates were. One declared that "he lived two years on ten cents." Money-lenders arrived almost simultaneously with the settlers. The chief money-lenders at first were agents of trust and insurance companies and representatives of banks. Implement dealers and merchants sold a large amount of their goods on credit to the setlers. Interest rates on money were high. Two per cent a month was a common charge on short-time loans. Interest charges on yearly loans ranged from fifteen to twenty-five per cent in the 'seventies, but dropped from these high rates to twelve and even to ten per cent in the 'eighties. Almost every community had a "loan-shark" who enriched himself at the expense of the less fortunate pioneers. After banks were established in the 'eighties, interest rates dropped materially.

Most of the stores did a big credit business. A number of pioneers said that, if a man could get some friend known to a merchant to vouch for his honesty and industry, the merchant would extend credit for a season on a large bill of goods. In the early days practically all the farm machinery was bought on credit and payment made at the end of the harvest season.

### HEALTH AND MEDICAL FACILITIES

The Palouse pioneer families had to adjust themselves to a situation of very limited medical facilities. Fortunately, the people were a healthy lot. Perhaps only the strong and the hardy risked the long journey to the Palouse Country. Not until the late 'seventies were trained doctors available in the country, and they were few and far between till well on in the 'eighties. When they became available, many of the people felt they could not afford them. To most pioneer families in the early days, a neighborly, untrained woman, with her natural gift for helping the sick and her kit of home-made remedies, a remedy for every ailment, was the chief medical aid. For many of the pioneers, the purchase of medical services was difficult, even when available. One old settler stated that he walked fifteen miles to a doctor to get his eyes treated, and then remained for several days at the doctor's home to saw and chop wood for him to pay the bill.

The worst epidemic that afflicted the people was that most dreaded children's disease—diphtheria. Several times it made severe ravages in various parts of the country. In one family it cut down five children in a few days. Many families lost two small children. In one community the disease took at least one child in almost every home. Once while many persons were gathered at the county seat, Colfax, during an Indian scare, the disease broke out and killed many children before it was checked. Other contagious diseases which brought serious affliction to some of the people were typhoid fever, scarlet fever, and smallpox.

Almost every local community had one or two neighborly women, usually rather elderly ladies, who treated all kinds of diseases and served as midwives. One pioneer woman reported that her mother rode all over the countryside on horseback with her saddle bags and kit of home remedies, responded to sick calls day and night, spent days at a time with families with sickness, helped at the birth of more than a hundred babies, and never in twenty years of her ministrations charged one penny for her services. These kindly women could do more than

prescribe home remedies. When families needed nurses they remained at the bedside with their patients. They were equally handy in the kitchen, at the sewing machine, and even at the wash tub. When death occurred, they often remained for several days to comfort the survivors.

By the late 'seventies trained doctors were beginning to arrive in the country. Though some of these physicians had had fair medical training, others, unfortunately, had not even attended a medical school, and were "self-educated" doctors. But on the frontier the people were sorely in need of doctors. Almost any one professing a knowledge of medicine could get a practice. In a few communities there were doctors who were equally proficient in ministering to man and beast. The writer was told of one pioneer doctor who advertised his versatility to his patients as being able to "treat men, women, children, Indians, horses, cattle, sheep, hogs, and poultry!" The old pioneer telling the writer of this versatile doctor added with a chuckle, "He had a big practice."

The pioneer doctors who located in the villages and in the open country in the 'eighties usually had an extensive practice extending out for a radius of eight to fifteen miles from their homes. They travelled almost exclusively by horseback. Some of the doctors rode a sort of circuit, appearing at different places and along roads and trails at more or less regular intervals. Any families which had sickness intercepted the doctor on his circuit and brought him to their homes.

The early Palouse pioneers had little comfort from preventive and particularly from "painless" dentistry. They depended chiefly on the travelling dentists who went about the country to ply their trade. These dentists rode from cabin to cabin, knocked on doors, and shouted across fields, "Anybody got any teeth to pull?" Though toothache is a painful disease, several of the old pioneers reported that the appearance of the travelling dentist was a signal for all youngsters to take to their heels. One of these dentists was reported to have weighed over two hundred pounds and to have proudly assured his patients, "When I get hold of a tooth, something has to come."

The medicine peddler completed the pioneer medical layout. He went about the country, calling at every cabin and selling his own mixtures or the standard patent medicines. His own mixtures were usually recommended over all others, because they had a much wider curative range.

That so many of the old settlers survived the period of pioneer medicine in the Palouse Country is testimony of both their hardiness and the proficiency of the practitioneers. Perhaps there was some truth in the statement of one old settler: "The only way you could kill them was with a sledge hammer."

NEIGHBORLINESS

The old Palouse pioneers are unanimous in reporting that the early families in the new country were very friendly and neighborly. Families visited frequently. When there was sickness in a family, neighbors invariably came in to help. Several pioneers remarked, "We were all just like one big family." Other remarks were: "The old pioneers were mighty good to one another," "In the old days nobody had much and all of us were alike," and "We had plenty of time to visit in those days." In the slack summer period between the spring plowing and planting and the late summer harvesting,[41] the pioneer families often visited kinsmen and friends at a distance, ten, twenty, or even fifty or a hundred miles away. The whole family was loaded into the wagon, bedding taken along, and a visit of several weeks made. It was common for families living only a few miles apart to spend the night with one another. If a man or his family became sick and could not plant or harvest his crop, the neighbors usually "pitched in and helped out." If a family was lacking in milk, potatoes, or other foods, neighbors shared with the unfortunate family what they had. A common type of fellowship was for several neighboring families to meet at a home and spend the evening singing.

The little country schoolhouses were used for many social events, including spelling bees, box-suppers, fiddlers' contests, Sunday Schools, dancing, debates, and literary programs. The school "exhibitions" always attracted most of the people of a neighborhood. Horse-racing was a favorite sport and many communities had special level flats set aside for this annual event.

Courtship had its special way among the young men and women of the Palouse. Young men always outnumbered the young women very considerably. Said one old pioneer, "If you wanted a date you almost had to get your bid in two months in advance." Young men taking their girl friends or sweethearts to different places always had the

[41] Harvesting of the wheat in the Palouse Country usually does not begin until the latter part of July or the first of August.

choice of one or two ways of transportation—horseback or the heavy farm wagon. The young women were usually as skillful riders as the young men. It was not uncommon for young couples to ride fifteen and twenty miles to attend events. The old square dance was the most common form of entertainment at the parties of young people. In the winter months when there was little or no farm work to be done, it was a common practice for the young folks to dance all night at their parties.

The general practice among the pioneers was to take in for the night the sojourner or stranger passing through the community. Rarely was a traveller asking shelter for the night turned away. The traveller often brought news of the outside world which was welcomed in the pioneer's home. One pioneer whose parents came to the Palouse Country in the late 'seventies and who lived on a main highway said that during the first ten years the regular charge made for a night's lodging and two meals was fifteen cents, and after the country was settled up, twenty-five cents.

Though very friendly and neighborly, the pioneers were critical and somewhat suspicious of strangers. New-comers to a community were treated kindly and hospitably, but also carefully scrutinized. The pioneers demanded honesty, sincerity, and integrity. If a new-comer was not "straight-forward and honest the community soon got rid of him." The undesirable intruder was first given a hint that his presence in the community was not desired. If this hint was not effective, more successful methods were used "to rid the community of him." One old pioneer said, "Only good honest folks could survive in our community."

### CHURCH AND SUNDAY SCHOOL

The Palouse pioneers had to adjust their religious customs to the new frontier conditions. They did not come as congregations, led by ministers, ready to set up religious institutions as exact duplicates of what they had left in the Middle West. They represented almost every religious sect. The earliest worship was the gathering of several families in a home and listening to some one "read the Bible and comment on the passage." Almost from the very beginning of settlement there were itinerant preachers "going about the country and calling at homes." Often when one of these ministers appeared in a community, "some one would get on a horse and ride over the neighborhood and invite everybody to come to the home of one of the neighbors for preaching."

Among the pioneers themselves there were also a few men who "mixed farming and preaching" and helped with religious services.

As soon as schoolhouses were built, they were used very extensively for Sunday School and preaching. The pioneers had often erected these schoolhouses out of private donations of timber and labor, and the feeling was that these buildings should be used for any purpose that the people of the community desired. The little schoolhouses were real social centers. The religious meetings in the schoolhouses were strikingly free from narrow denominationalism. Preachers of any denomination were welcome to preach, and the whole community usually turned out to hear them regardless of creeds. A number of pioneer women stated that they taught Sunday School classes in the little schoolhouses ten, fifteen, and twenty years, rarely missing a Sunday. One interesting effect of the extensive use of schoolhouses for religious services in the Palouse Country was to keep denominational churches from being built. There are very few such churches in rural communities of the Palouse Country today. In some communities the little schoolhouses are still used for Sunday Schools, though rarely for preaching.

The biggest religious event of the year for the pioneers was the annual campmeeting, which usually came during the month of June or early July. The writer learned of about a dozen of these early campmeeting places in the Palouse Country. They were usually shady spots in pleasant groves close by a good spring, and a big tent was stretched up in an open place. The people came in their wagons from distances of ten, fifteen, and twenty miles. They slept in their wagons and cooked their meals over open fires. The meetings usually lasted for a week or ten days. Preachers of several denominations would be on hand to do the preaching. Occasionally two ministers of different creeds would engage in a debate on some doctrinal points. Some old pioneers related that these debates were the most interesting part of the meetings.

In one community a horse-racing track was only a quarter of a mile away from the campmeeting grounds. The annual horse-racing and the campmeeting were always held at the same time, and the crowds alternated back and forth between the religious services and the horse races. Care was taken in the scheduling of the religious services and the races to see that there were no conflicts in the time when sermons were preached and the races run. One old pioneer who said he "never missed a service or a race," with a mischievous twinkle in his

eye, added, "There was always more money for stakes than for the preachers."

The campmeeting was a welcome social event in the life of the pioneers. "At campmeeting, you always saw all your friends," said one old lady. One old pioneer leading the writer to a spot in the woods where a campmeeting was held for many years suddenly paused and became silent. Then he said: "You can't imagine the memories this place brings back to me. Here I had the happiest days of my boyhood."

### SCHOOLS

In providing school facilities for children in the 'seventies, the pioneers showed marked resourcefulness in adjusting themselves to pioneer conditions. Though a few of the old pioneers reported that their communities were without any school facilities at all for a few years, most of them told of various provisions for schooling. Frequently a settler with several children "rigged-up" a room in his own home for a school, or built a shack in his yard, and invited neighbors to help him employ a teacher and send their children to school. Often the teacher was the already overburdened settler's wife, or his young daughter. Sometimes the teacher was an itinerant. These subscription schools lasted only a few months in the year. The itinerant teachers passed from one community to another and taught in several communities in the course of a year.

As soon as there were enough people in a community for a public school, application was made for the formation of a public school district. The best way to get the application passed on favorably by the county school officials was for the pioneers to agree to furnish the materials and build the schoolhouse. Then public funds would be provided for the employment of a teacher. The first schoolhouses were usually little shacks twelve and fourteen feet square. In a number of communities crude homesteaders' cabins were converted into schoolhouses. School attendance, however, was none too good in the early pioneer days. Boys were often kept out of school herding farm animals and riding errands. One pioneer reported that in his community in the late 'seventies there were "not over twenty children in school, when there should have been three or four times that number."

The pioneers reported that schooling was generally "poor" in the early days. Few of the teachers were well prepared to teach. There were many men teaching just to earn a few dollars "to get started in

something else." The schoolhouses were poorly equipped. It was difficult to get books and other school supplies. The schools were not graded. One pioneer said, "A 'scholar' was graded by how far he had gone in arithmetic."

In the 'eighties several high schools and academies were established in the small towns in the Palouse Country. However, the so-called "high schools" of the day were scarcely high schools at all. One old pioneer who said he was one of the first graduates from one of these high schools remarked that he had "about an eighth grade education" when he graduated.

An aspiring denominational (Baptist) college was established in the county seat of Colfax in the late 'seventies. A number of the pioneers told of attending this little college in the 'eighties. A Catholic academy was also established in the county seat in the 'eighties.

### MAIL AND NEWSPAPERS

In the early 'seventies the Palouse settlers, except those living on the Snake River, were very much isolated so far as mail and newspapers were concerned. Three pioneers reported that their families received mail only once during their first year in the country. Several others reported that letters and papers coming to their families from the Middle West were a whole year reaching them. Many settlers depended for news on what they could get from neighbors. Every settler was a "news man passing on what he heard to everybody else." Social gatherings were "gossip parties."

Some of the settlers had friends or kinsmen down in Oregon or the Walla Walla country, where mail arrived more frequently and regularly, who would save up a six or eight months' supply of newspapers and send them by a traveller, a freighter, or a stage-driver to their isolated friends or kinsmen in the Palouse Country. These bundles were dropped off at stores and other places and then picked up by the settlers.

In the late 'seventies star mail routes were extended to certain parts of the Palouse Country. Post-offices were established at country stores, in private homes, and in the villages. Till in the 'eighties mail was brought only once a week to these frontier post-offices. Settlers living five and ten miles distant from the post-offices cooperated in taking "turns" in bringing in the mail for several families.

By 1880 several local Palouse papers were being published in the small towns. But for many years a number of Palouse settlers continued to subscribe to the local weekly papers from the old homes in the Middle West. None of the settlers reported receiving daily newspapers in their homes during the 'seventies and 'eighties. Papers other than the local weeklies received were the weekly editions of such papers as the New York *Sun,* the New York *Tribune,* and the Portland *Oregonian.*

PIONEER PROTECTION

For more than a decade after the first arrivals, Palouse pioneers were still haunted by fear of the Indians. A number of the settlers were escorted from Walla Walla to the Palouse Country by a troop of United States cavalry. Though the Indians of the eastern Washington area had been brought under control and set off in separate reservations in the late 'fifties and early 'sixties, they still travelled extensively over the Palouse Country. Only a few miles east of the Palouse area, over in Idaho, the Nez Perce Indians under Chief Joseph were very restless, as attempts were being made to confine them in smaller reservations. Small bands of Indians riding through the country occasionally stopped at schoolhouses and went through motions of scalping, to the consternation of children, teachers, and parents. Sometimes Indians would ride up to a lone cabin, when the man was away at work and only the wife and children at home, and go through the kitchen pantry helping themselves to what they could find. The early settlers were thus kept in a state of fear by the Indians.

In June, 1877, a real Indian scare spread over the Palouse country. From across the Idaho border to the east news came that several thousand armed Indians had gone on the warpath against white settlers, and that they were moving west and would soon cross the Clearwater River into the Palouse Country. Men and boys jumped on horses and rode from cabin to cabin spreading the alarming news. Many families packed up supplies and rushed toward Colfax, the county seat. Some fled to Walla Walla. In a number of communities the settlers gathered at strategic points and rapidly constructed small log forts, into which they planned to retreat if attacked. In several remote communities the people gathered at their little schoolhouses, barricaded the buildings, dug pits, and threw up ramparts to withstand attack. In two communities the alarm arrived just as the people were in the midst of

their annual campmeetings, and the men immediately turned to constructing forts for protection.

At Colfax, where many settlers and their families had gathered, a militia was hastily organized. Sentinels and outer guards were posted on the hills overlooking the town. Scouts were sent out toward the Clearwater country to find out whether the Indians were crossing the river. Many old settlers have keen recollections of the many campfires which burned along the banks of the Palouse River in the village of Colfax as the people anxiously awaited further news of the Indian march. One old settler, after describing the gallant defense of the village, said, "And we didn't have enough ammunition to fire half a dozen rounds."

Settlers remained away from their homes anywhere from several days to two months. Many men returned to their homes every few days to look after the stock. In one community the settlers left the care of their stock to friendly Indians living in a nearby reservation. When settlers returned to their homes they found little or no damage had been done to their homes in their absence. Some cabins had been broken into and the pantries robbed. Some livestock had been driven away. A few lone settlers had been killed by irresponsible renegade Indians. The Nez Perce Indians under Chief Joseph had never marched toward the Palouse Country at all, but were retreating into western Montana, headed for Canada, to escape being confined to a smaller reservation in Idaho. It was all a useless scare, but the story of it is still related by all old pioneers as perhaps their most vivid recollection of the early Palouse days.

The pioneers who lived in the small villages in the early days remember that rowdy, lawless young men came to town, got drunk, rode their bucking broncos into stores and saloons, flourished their guns, chased the policeman or the constable into hiding, and occasionally engaged in a "free-for-all" in the streets. One pioneer said that his village in the early days had "gunmen, knife-men, and club-men," all of whom "had to be looked out for." Another pointed out to the writer the spots on main street where he had seen three men killed in the early days. Still another pioneer gave it as his opinion that "about ninety per cent of the young men coming into the village were rough fellows, armed and ready to shoot on small provocation." Against these "rough fellows" the law-abiding citizens had to maintain law and order the best they could. In one village that became an important cattle-

assembling point, the citizens expected to have several "rough weeks" when all the cowboys came in for the annual round-up. One old store proprietor showed the author the bullet marks still plain after fifty years in the walls of his building as a result of a Saturday-night cowboy mix-up. Occasionally when the disturbance became too great the enraged citizens combined, took the law into their own hands, and dealt out quick and decisive "popular justice" to the disturbers.

Perhaps the worst form of lawlessness from which the early Palouse settlers suffered was cattle and horse stealing. During the late 'seventies, through the 'eighties, and even into the 'nineties, gangs of stock thieves operated through the country. One set of thieves operated over an area from eastern Oregon, through the Palouse Country, and on into northern Idaho, western Montana, and even into Canada. These sections were just being settled during that period, and horses were in great demand. The horses were usually stolen and driven away at night, hidden in coves and secluded spots during the day, and driven over the next lap the following night. Hiding places were maintained about twenty-five miles apart, a night's run with the horses. It required twenty years of organization and effort on the part of the settlers to break up this notorious ring of horse thieves.

More difficult to detect and catch was the cattle and horse rustler, who was a neighbor living in the community, and who ostensibly lived as a law-abiding and respectable citizen, but whose mysterious night-riding and sudden possession of strange horses and cattle in his lots and pastures caused suspicion among neighbors. On the frontier, horse and cattle thieving was a most serious charge to bring against a man. No man dared hint at such a charge unless he had very good evidence. With all its open friendliness and neighborliness the frontier community often had a family or two that never told anything about their origin or the sources of their prosperity. One pioneer pointed out to the writer a house and farm from which a father and two sons, who were apparently good citizens for many years, were finally sent to the penitentiary for horse and cattle stealing. In another community eight men were finally rounded up, forced to plead guilty, and sentenced to penitentiary terms of from one to eight years each. The pioneer juries had little mercy on horse and cattle thieves.

Horse and cattle stealing was not stamped out of the Palouse communities until the settlers organized local stock protective associations. These associations were organized on the plan of secret lodges,

and members were taken into the associations only after they had passed the blackballing ordeal of their neighbors. If any man being considered for membership in an association was blackballed, his case was turned over to a special committee for close scrutiny of his past record. Under this severe grilling a number of men confessed their past sins, repented, and gave assurances of their proper respect for their neighbors' livestock in the future. The protective associations drove many suspected men from the communities, and they made the communities safe for livestock.

In conclusion, the writer of this article expresses the hope that rural sociologists and other social scientists will give more attention to the historical study of rural social life. Several dozen studies in different parts of the country would give the rural sociologists a body of comparative data that would help fill in one of the gaps in rural sociology, and also give a more substantial basis for the interpretation of recent social trends in rural America.

# THE NUMBER OF UNINCORPORATED PLACES IN THE UNITED STATES AND THEIR ESTIMATED POPULATIONS[1]

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## I. THE PROBLEM

Rural social organization in the United States is characterized by isolated farms with villages dispersed at intervals throughout the countryside. Unlike the farmers in rural areas of many nations where a considerable proportion of them live in villages and go out daily to their farms, farmers here have chosen to live on isolated farms. The hamlet or village for them exists as a service unit. The hamlets and villages of the United States represent, therefore, a specialization of social and economic functions, a nucleus of community life in a nation of isolated farms. In addition to this great majority of places whose primary function is farm trade are other places whose chief functions are such activities as mining, fishing, lumbering, shipping, or other industries.

Of the places with less than 2500 people, only a small proportion are incorporated. Unless incorporated, a place lacks separate and independent legal status, but nonetheless it may play a significant and unique part in the life of the countryside. In spite of the great importance of places with less than 2500 people in the national life, little information concerning their total numbers and their total population is available. The decennial reports of the United States Census, the only official statistical summary of places and population of a nationwide character, record separately the population of incorporated places, however small they may be, but do not report unincorporated places or their populations separately. In fact, the population of unincorporated

[1] Acknowledgment is made to the Dun and Bradstreet Company for the loan of their files of rating volumes; to the National Youth Administration of the State College of Washington for clerical assistance; to the following students of the rural community and others for a critical reading of the manuscript: Dr. C. C. Zimmerman, Professor of Sociology at Harvard University; Dr. Dwight Sanderson, Head of the Department of Rural Social Organization at Cornell University; Dr. Lowry Nelson, Professor of Rural Sociology at the University of Minnesota; Dr. Willard L. Thorp, Director of Economic Research, Dun and Bradstreet; and Dr. Leon E. Truesdell, Chief Statistician for Population, Bureau of the Census. All have made valuable suggestions. The author assumes full responsibility for all data, statements, and interpretations.

places is included with that of the open country under the general classification "rural population."[2] For the years 1920 and 1930 the Census has subdivided the rural population into two classifications—rural farm and rural non-farm—the rural farm population consisting of people living on farms[3] and the rural non-farm population of all other rural people, whether living in villages, hamlets, or open country.

The need for information on the total number of villages and hamlets in the nation and on the number of their populations has been felt keenly by rural sociologists, population authorities, and others concerned with rural life. C. Luther Fry, while working on the staff of the Council of Social and Religious Research, published population estimates for 1920 for unincorporated places with 250 to 2500 population, employing population estimates appearing in the *Rand McNally Atlas* for unincorporated places and Census figures for incorporated places.[4] This is the only such information available for any census year. Fry's data lack completeness, however, for all places with fewer than 250 people are omitted.

This paper outlines the method and the results of an attempt to arrive (1) at a rough estimate of the total number of places with fewer than 2500 people in the nation, unincorporated and incorporated, at four census intervals (1900, 1910, 1920, and 1930), and (2) at a rough estimate of the total population in these places, classifying all places with fewer than 2500 people into three units: hamlets, places with less than 250 population; small villages, places with 250-999 population; and large villages, places with 1000-2499 population.

## II. METHOD OF PROCEDURE

The Bradstreet Company, Incorporated, has published since 1854[5] the *Bradstreet's Book of Commercial Ratings*, which lists all places in the United States having mercantile enterprises. This record provides

[2] Rural population includes people living in the open country and in all places with less than 2500 people.

[3] A farm, as defined by the Census, is a tract of three acres or more being farmed or a smaller tract marketing $250 worth or more of produce per year.

[4] C. Luther Fry, *American Villagers* (New York: George H. Doran Company, 1926), Chap. 3.

[5] The company was merged with the Dun Company in 1933. The Dun and Bradstreet Company then replaced the Bradstreet series and the Dun series of rating volumes with the new Dun and Bradstreet series, which has followed for the most part the form of the old Dun volumes. Rating volumes are published four times a year.

the list of unincorporated places studied. For these places, whether incorporated or unincorporated, Bradstreet's gives the estimated population.[6]

Obviously, population estimates, even when made by a resident of a village, admit of considerable error. An attempt was made to correct for this error. Since estimates are published for both incorporated and unincorporated centers, a corrective procedure was possible.

By a comparison of the Bradstreet population estimates for incorporated places, which appear before Census figures are available, with the Census figures for a given year, it is possible to arrive at an approximation of the degree of error in the Bradstreet figures. If Bradstreet figures tend to run high, estimates may be reduced accordingly; if they tend to run low, they may be raised by the necessary amount. The corrective formula is

$$\frac{\text{Census population for incorporated places}}{\text{Bradstreet estimate for incorporated places}} \times \begin{array}{c}\text{Bradstreet population estimate}\\ \text{for unincorporated places.}\end{array}$$

For example, the United States Census gives a total population of 63,013 for large villages (1000-2499 population) for the state of Washington for the year 1930. Before the Census data were available in published form for these incorporated places, Bradstreet had published estimated populations. These estimates showed 65,429 population for incorporated places of this size. The formula then becomes $\frac{63{,}013}{65{,}429}$, which gives a corrective index of 0.96. All Bradstreet estimates for unincorporated places are multiplied by this index and thus, in this instance, properly reduced. Had Bradstreet underestimated incorporated places, the index would have been over 100 and would have had the effect of raising estimated populations of unincorporated places.

It was found necessary to work out a corrective index for each state for each Census year. The index for one state does not always reflect conditions in an adjoining state for the same year, nor does a state always show the same degree of error in estimates decade after decade, although it frequently does so. Because varying degrees of

[6] These population estimates are made by company reporters who ordinarily reside in each place (this would not be true of very small places) and who make up quarterly credit ratings of merchants in the village. January volumes were used for 1900, 1910, and 1920, and the March volume for 1930. These happened to be the volumes lent by the Dun and Bradstreet Company.

error exist within groupings of places, a different corrective index was used for each grouping.[7]

The following procedure was followed throughout in arriving at the summaries presented in this study. Census figures were used for all incorporated places. Corrected Bradstreet figures were used for unincorporated places. A corrective index was worked out and applied to Bradstreet's population estimates for the four Census years studied (1900, 1910, 1920, and 1930), a separate index being employed for each state for each year and for the 0-249 group, the 250-999 group, and the 1000-2499 group.[8]

One should not maintain that this corrective procedure gives entirely accurate figures for the various classes of places. There is considerable tendency for the Bradstreet volumes to carry Census data from the preceding Census unless there have been marked changes in population. Accordingly, in many instances, when one compares the Census data with the Bradstreet data for incorporated places, he is actually comparing the 1930 Census data with the 1920 Census data. To eliminate completely this factor for the various states would involve considerably more statistical adjustment than a study of this character merits.

There is some fallacy in even assuming that unincorporated centers grow at the same rate as incorporated centers and any corrective index must be based on this assumption. Lively has indicated that in Minne-

[7] Generally speaking, places with under 250 population are overestimated, population estimates tending to be about one-fourth higher than the Census counts. The 250-999 population group during the first two decades is more often overestimated than underestimated, but for the last two decades about as many places are underestimated as overestimated, the error in each direction being about ten per cent. The 1000-2499 group almost universally is underestimated by about one-fourth.

[8] The only exceptions are the following: No corrective index could be employed for New Hampshire, Massachusetts, and Rhode Island because small places in those states are not incorporated. (These states seldom incorporate places of less than 5000 population.) Too few places are incorporated in the following states to serve as a basis for correction: Maine, 0-249 and 250-999 groups, all years; Vermont and Connecticut, 0-249, all years; New York, 0-249, 1900; New Mexico, Utah, Nevada, and California, 0-249, all years. No corrective index could be developed for Arizona for any period for the 0-249 group because no places in this group were incorporated. The same was true for New Mexico in 1900 and for Nevada in 1900 and 1910. Uncorrected Bradstreet data were employed in all of these cases. Also, there were several instances where all places with 1000 to 2499 population in a state were incorporated and therefore listed in the Census: namely, South Dakota, 1910, 1930; Deleware, 1900, 1910, and 1920; North Dakota, all years. In these cases official Census data only are used.

sota the tendency is for unincorporated centers to grow at a less rapid rate than incorporated centers[9]

Correction by the method indicated tends to take care of the grosser error tendencies that are to be found in the estimates but cannot correct all of them. *The data presented are at best only estimates. They are of value chiefly because no other information exists* (excepting the Fry estimates previously mentioned covering the 250-2499 group for the year 1920). The roughest kind of approximations are better than no information at all on this important topic. Data presented concerning the 0-249 population group are the most speculative, those on the 1000 to 2499 group least speculative, because few of the former group of places are incorporated, whereas a majority of the latter group are.[10] The 250-999 population group is intermediate in accuracy. Data for New England are too speculative to be of any value. They are included here only to complete in a rough way the national picture. So few small places in New England are incorporated, and town and township in Bradstreet estimates for that area are so frequently confused, that the method employed in this study has no validity for that geographical division.

### III. A COMPARISON OF THE BRADSTREET DATA FOR PLACES WITH 250-2499 POPULATION WITH DATA FROM THE *Rand McNally Atlas* AND *Cram's Atlas* FOR TWELVE SAMPLE STATES

C. Luther Fry, in his pioneering work in this field, using data for 1920, compared twelve widely scattered states with respect to the number of places with 250-2499 population and their estimated population reported in the *Rand McNally Atlas* and reported in *Cram's Atlas*.[11] Table I compares his findings with my findings based on the Bradstreet volume. This is as good a check of reliability as can be obtained without field enumeration of sample areas and, interestingly enough, shows that all three sources give fairly comparable results.

Cram lists more places than either of the other two sources in each of the sample states. In most states the number listed by Rand McNally is higher than that listed by Bradstreet. The chief exceptions are New York and Ohio, for which Bradstreet lists a much greater number of

[9] C. E. Lively, *Growth and Decline of Farm Trade Centers in Minnesota, 1905-1930* (St. Paul: University of Minnesota Agricultural Experiment Station, Bulletin 287, July, 1932), p. 21.

[10] In a few states all of the places in this group are incorporated, although in some others none of them are incorporated. See Table 11.

[11] Both the Rand McNally and Cram atlases were published in 1921.

places; in fact, the excess in those states is so great that it causes the Bradstreet total for the twelve states combined to show a greater number of places than the *Rand McNally Atlas.* The purpose of the agencies probably explains somewhat the number shown. Bradstreet, being a mercantile listing agency, lists only those places which have one or more mercantile enterprises—that is, places of trade. There need be no population in such places. The other publications are atlases and doubtless use another criterion, probably population aggregrates, rather than business enterprises. Regardless of which source is used, it is apparent that results are not far different. The difference between Rand McNally and Cram, the two which differ the most, is only about six per cent.

The Rand McNally population data and the uncorrected Bradstreet data are lower than the Cram estimates for most states. Rand McNally and Bradstreet data are approximately the same as far as the total number of people is concerned. For some states the *Rand McNally Atlas* lists more population than Bradstreet; for others Bradstreet lists more than Rand McNally.

The corrective procedure for all places between 250 and 2499 population has the effect of raising the uncorrected Bradstreet data for all the states combined, but for five of the twelve states it has the effect of lowering the population estimates. The actual difference between the uncorrected Bradstreet and the corrected Bradstreet estimates for all the states combined is only about 100,000. The corrected Bradstreet data tend on the whole to run between the Rand McNally and Cram listings, the Rand McNally data being low and the Cram data being high.

If data for places of under 250 people listed by the Cram and Rand McNally atlases were available for comparison, it is possible that much greater differences between these data and the Bradstreet data than those appearing in the table would be observable, both for number of places and for population. Most places of over 250 people undoubtedly are listed both by commercial rating agencies and by atlases, but it is debatable whether a place with only a few people would appear in an atlas. The Bradstreet volumes often list a place with no population, provided it has a mercantile enterprise.[12] Such a place might not appear

[12] Some places without mercantile establishments at a given year appear in the volumes, for the reports of the company carry for a period of eighteen months places where business enterprises have ceased to function. If the enterprises remain inactive after this period the places are dropped.

Table 1. A Comparison of the Rand McNally Atlas and Cram's Atlas with Bradstreet's Commercial Ratings in Respect to the Number of Places with 250-2499 Population for Twelve Selected States, and in Respect to the Population of those Places as of 1920[a]

| | Number of places 250-2499 population | | | Population in places 250-2499 population | | | |
|---|---|---|---|---|---|---|---|
| State | Rand McNally | Cram | Bradstreet | Rand McNally | Cram | Uncorrected Bradstreet | Corrected Bradstreet |
| Pennsylvania | 1590 | 1750 | 1585 | 1,170,580 | 1,233,593 | 1,153,524 | 1,292,419 |
| New York | 1108 | 1262 | 1182 | 731,358 | 918,050 | 863,856 | 844,596 |
| Ohio | 878 | 912 | 909 | 596,011 | 605,663 | 597,956 | 609,340 |
| Illinois | 934 | 963 | 933 | 711,468 | 724,346 | 712,513 | 715,981 |
| Iowa | 663 | 667 | 665 | 470,069 | 473,536 | 470,765 | 471,854 |
| Missouri | 612 | 622 | 606 | 439,786 | 433,464 | 424,317 | 423,426 |
| Georgia | 457 | 467 | 450 | 311,172 | 314,266 | 305,086 | 310,170 |
| Alabama | 388 | 432 | 394 | 271,160 | 289,681 | 278,601 | 295,923 |
| Idaho | 146 | 159 | 145 | 97,355 | 98,603 | 97,022 | 92,595 |
| Colorado | 190 | 206 | 186 | 131,497 | 137,608 | 127,770 | 127,049 |
| Washington | 299 | 308 | 286 | 191,769 | 196,513 | 184,944 | 182,127 |
| California | 520 | 534 | 507 | 384,361 | 394,898 | 373,836 | 320,507 |
| TOTAL | 7785 | 8282 | 7848 | 5,501,586 | 5,820,221 | 5,585,170 | 5,683,282 |

[a]In all instances Census data are used for the population of incorporated places, the other sources (Rand McNally, Cram's, and Bradstreet) for unincorporated places). The Rand McNally and Cram data are from C. Luther Fry, American Villagers (New York: George H. Doran Company, 1926). p. 28.

Table 2. Growth Trends in the Number of Hamlets, Villages, and Cities in the United States by Decades, 1900-30

| | Hamlets | | Small villages | | Large villages | | All places (0-2499) | | Cities (2500 and above) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Number | Per cent | Number | Per cent | Number | Per cent | Number | Per cent | Number | Per cent |
| 1900 | 58,403 | | 12,130 | | 5349 | | 75,882 | | 1801 | |
| 1910 | 56,837 | -2.7 | 14,628 | 20.6 | 3971 | 18.6 | 75,436 | 2.1 | 2313 | 28.4 |
| 1920 | 43,684 | -23.1 | 14,838 | 1.4 | 4246 | 6.9 | 62,768 | -16.8 | 2787 | 20.5 |
| 1930 | 37,20[illegible] | -14.8 | 14,871 | .9 | 4401 | 3.7 | 56,575 | -9.9 | 3165 | 13.6 |

Table 3. Trend in Incorporation of Hamlets and Villages by Decades in the United States, 1900-30

| | Hamlets | | Small villages | | Large villages | | Total places | |
|---|---|---|---|---|---|---|---|---|
| Year | Number incorporated | Per cent incorporated | Number incorporated | Per cent incorporated | Number incorporated | Per cent incorporated | Number incorporated[a] | Per cent incorporated |
| 1900 | 1608 | 2.8 | 5057 | 41.7 | 2090 | 62.4 | 8755 | 11.8 |
| 1910 | 2401 | 4.2 | 6703 | 45.8 | 2715 | 68.4 | 11,819 | 15.7 |
| 1920 | 2436 | 5.6 | 7083 | 47.7 | 2983 | 70.3 | 12,503 | 19.9 |
| 1930 | 2982 | 8.0 | 7370 | 49.2 | 3086 | 70.1 | 13,438 | 23.8 |

[a]Figures in this column differ slightly from Census data because of a difference in method of handling places on state lines. The amount of difference for a given year varies according to the Census volume used for comparison. For example, the 1900 Census lists a different number of incorporated places of under 2500 population than does the 1910, 1920, or 1930 Census for the same year.

Table 4. Growth Trends in the Number of People Living in hamlets and Villages in the United States by Decades 1900-30

| | Hamlets | | Small villages | | Large villages | | Total places | | Total population United States |
|---|---|---|---|---|---|---|---|---|---|
| Year | Number | Per cent increase | Number | Per cent increase | Number | Per cent increase | Number | Per cent increase | Per cent increase |
| 1900 | 2,927,895 | | 5,482,513 | | 5,382,833 | | 13,793,241 | | |
| 1910 | 3,146,887 | 7.0 | 6,852,494 | 20.0 | 6,622,375 | 18.7 | 16,621,756 | 17.0 | 21.0 |
| 1920 | 2,688,309 | -17.1 | 6,995,164 | 2.0 | 6,734,501 | 1.7 | 16,417,974 | -1.2 | 14.9 |
| 1930 | 2,515,760 | -6.9 | 7,191,472 | 2.7 | 7,119,703 | 5.4 | 16,826,935 | 2.4 | 16.1 |

in an atlas. On the other hand, places with a small population aggregate but without mercantile enterprises would not be included in the rating volumes but would probably appear in an atlas. Therefore the number of places of under 250 people likely to be found depends somewhat upon the criteria for selection.[13] These differences in places studied, however, should affect only slightly the aggregate population, as places omitted from any list are likely to have only a small resident population.

This study includes all places listed in the *Bradstreet Book of Commercial Ratings,* regardless of whether or not they have a resident population reported. There is some justification for this procedure. In the United States, where farmers live in the countryside on individual farms, any place of trade represents a differentiation of social function and a specialization of economic activity. Moreover, even the smallest of such places often is the focus of a rural community. This was especially true in the pre-automobile days, when the general store was a basic rural institution.[14]

## IV. FINDINGS FOR THE NATION

*A Statistical Summary of Growth Trends in Numbers of Places of under 2500 Population in the United States by Decades* (Table 2). The number of places with 0-2499 population reported by Bradstreet for the United States reached its climax in 1910, when there were 75,436 places. During the following decade the number decreased 12,668, or 16.8 per cent, and during the decade 1920-1930 it dropped

[13] Even where agencies use the same criteria, differences are apparent. Previous to the merger of the Dun and Bradstreet companies in 1933, each company listed places for commercial rating. Yet a comparison of a sample of the two companies' lists by Dr. Willard L. Thorp, Director of Economic Research, Dun and Bradstreet Company, Inc., shows that, whereas the companies report about the same number of places, about 10 per cent of the places apearing in one list do not appear in the other. Reported in a letter to the author, November 23, 1937.

[14] General stories have suffered a marked decline since the coming of the automobile. In South Dakota they fell from a peak of 1452 in 1911 to 1130 in 1931. See Paul H. Landis, *South Dakota Town-Country Trade Relations* (Brookings: South Dakota State Agricultural Experiment Station, Bulletin 274, September, 1932), p. 17. In Washington they fell from 1264 in 1920 to 794 in 1935. See Paul H. Landis, *Washington Farm Trade Centers, 1900-1935* (Pullman: Washington State Agricultural Experiment Station, Bulletin 360, July, 1938), p. 26. Today, in the larger villages, department stores have developed in the place of the general store.

6,193, or 9.9 per cent. In 1900, 73,882 places were listed; in 1930 there were only 56,575.

This decrease is explained by a rapid decline in the number of hamlets listed. It will be observed that during each decade of this century the number of hamlets reported has declined, but the period from 1910 to 1920 saw the most marked decline, a decrease of almost one-fourth.

Without doubt a part of the extreme fluctuation in the number of hamlets grows out of the character of the source rather than from historical fact. Although there was no change in the listing policy of the Bradstreet Company, Leon E. Truesdell has demonstrated that the character of the lists is responsible for certain extreme fluctuations in four counties in Massachusetts, where he checked Bradstreet data assembled by the writer against historical fact.[15] To what extent these factors effect the marked drop in hamlets throughout the nation during the decade 1910 to 1920, it is not possible to say.[16] The writer knows from personal observation and study in the Great Plains region and in the far West that many crossroads stores and hamlets actually disappeared with the coming of the automobile, rural route, and surfaced highway.

There is another factor to be considered. The disappearance of the hamlet as a place of trade, which would eliminate it from the

[15] The situation is probably worse in New England than in any other region. inasmuch as no villages are incorporated there and village and town (township) are often confused.

[16] The following explanation was received from Doctor Thorp's office, March 14, 1939:

"Two causes, not directly related, are responsible for the disappearance of so many small towns from the Dun & Bradstreet Reference Book. The first was the closing of many post offices during the first decade of this century. The closing of the post offices did not necessarily cause the small towns or hamlets themselves to disappear. However, as a matter of convenience both to the merchants located in and around these hamlets and to Dun and Bradstreet in reporting these merchants, the small towns were in many instances removed from the Reference Book and the names of the merchants at such points were transferred to the towns from which they received mail by rural delivery. By no means was every town deleted from the Reference Book simply because the post office was discontinued. Thousands of these towns, either because of their importance in size or as a matter of convenience, remained in the Reference Book and still remain with a notation in each instance referring to some other town as the post office.

"The second cause was the building of improved highways and transportation by automobile. In many instances the towns actually disappeared as a result, irrespective of whether or not the post office had been discontinued. Often a little town would be missed by a new main highway and due to the diversion of traffic and trade, the town would simply dry up and disappear."

Bradstreet list of places, does not necessarily mean that it always disappeared as a small population aggregate, although undoubtedly very often the place may also have disappeared as a population unit. Of course, many of these places never had a resident population, and others had only a few residents.

A rapid decline in hamlets was brought about after 1910 by the rapid expansion of surfaced highways and the coming into use of the automobile. The rural route, established in 1895, grew rapidly with the increased use of the automobile and the year-round road. (Rural routes increased from 28,685 miles in 1900 to 933,068 miles in 1910, had expanded to 1,151,832 miles by 1920, and had reached 1,344,842 miles by 1930.) The parcel post system, which was originated in 1913, came into universal use. These combined developments had the effect of destroying the fourth-class post office, which had been a very important bond between the hamlet and the farm population. Many hamlets disappeared with the passing of the fourth-class post offices, for these post offices were often located in the general store. (The number of fourth-class post offices in the United States decreased from 72,408 in 1900 to 51,955 by 1910, to 41,102 by 1920, and to 33,404 by 1930.) The farmer had to come to the hamlet to get his mail. With the coming of rural route service his regular visits to the hamlet ceased. The use of the automobile made possible frequent trips to larger villages, so that the hamlet was no longer indispensable as a service center for people in rural territory.

Places with 250-999 population have tended to increase, but at a rapidly failling rate. During the first decade of the century, they increased by over one-fifth, but during the following decade, when the nation experienced the revolution in transportation and communication previously discussed, they increased by only 1.4 per cent and during the last decade they increased by only 0.9 per cent. The same influences that affected the hamlet of under 250 people have no doubt been at work to decrease the importance of the small village to the open country population.

Places with 1000-2499 population follow a trend similar to that of the 250-999 group, but not so extreme. During the first decade of the century the increase for this group was somewhat less than for small villages, 18.6 per cent as compared to 20.6 per cent, but during the second decade the increase was 6.9 per cent and during the third decade 3.7 per cent.

At the same time cities in the nation have shown a higher percentage of increase during each decade than any other group of places, although they also show a falling rate of increase as far as their numbers are concerned, the increase in the first decade being 28.4 per cent and in the last decade 13.6 per cent. The increase in number of cities is due no doubt in large part to growth of places which had less than 2500 population at the preceding Census and which since have passed the 2500 mark.

*A Statistical Summary of Incorporation Trends of Places of under 2500 Population in the United States by Decades* (Table 3; also refer again to Table 2). Places with 0-2499 population in 1900 numbered 73,882. The number in 1910, when they reached their peak, was 75,436, of which 11,819, or 15.7 per cent, were incorporated. By 1920 the total number had fallen to 62,768, but the number incorporated had risen to 12,503, which was 19.9 per cent of the total. By 1930 the total number had fallen to 56,575, but the number of those incorporated had risen to 13,438, or 23.8 per cent of the total.

The number of hamlets has decreased during each decade, having fallen, as we have seen, from 58,403 in 1900 to 37,203 in 1930, but the percentage incorporated has risen from 2.8 per cent in 1900 to 8.0 per cent in 1930. Small villages have increased only slightly in numbers, but the proportion incorporated has risen from 41.7 per cent in 1900 to 49.2 per cent in 1930. There has been little change since 1910. Large villages have increased considerably in numbers but the percentage incorporated has changed little.

*A Statistical Summary of the Population of Places of under 2500 People in the United States, 1900-1930.* (Table 4). There were 13,793,241 people living in all places of under 2500 population in 1900. By 1930 this number had increased to 16,826,935. During the first decade of the century there was an increase of 17 per cent; between 1910 and 1920, a decrease of 1.2 per cent; between 1920 and 1930, an increase of 2.4 per cent.

The population living in hamlets increased by seven per cent during the first decade, decreased during the second decade by 17.1 per cent, and decreased during the last decade by 6.9 per cent.

The number living in small villages increased during each decade, but the increase was small except during the first decade, when the number increased 20 per cent.

The population in large villages increased 18.7 per cent during the first decade, 1.7 per cent during the second decade, and 5.4 per cent during the last.

During no decade did any group equal the increase of the national population.[17] During each of the last two decades, when population of places of under 2500 population has been practically stationary, the national population has increased about 15 per cent.

*The Percentage of Population of the United States in Three Groups of Places by Decades, 1900-1930* (Table 5). The percentage of population in all places of under 2500 people living in hamlets has fallen during each decade, dropping from 21.2 per cent in 1900 to 14.9 per cent in 1930, whereas the percentage living in small villages and large villages has increased slightly. It is interesting to observe that the percentage living in the two classes of villages has been about the same for each census interval.

*Percentage of National Population in Places of under 2500 People by Decades* (Table 6). The percentage of the nation's population living in places of under 2500 people has decreased consistently during each decade since 1910, falling from 18.2 per cent in 1900 to 13.7 per cent in 1930. Stability characterized the decade 1900-1910, but there was a considerable decrease during each decade since 1910.

The proportion living in hamlets has decreased consistently during each decade. In 1900, 3.9 per cent of the nation's population lived in hamlets; in 1930 only 2.0 per cent. A slight increase was registered in the percentage living in the other two groups during the decade 1900-1910. Since that time there has been a consistent decline. The proportion living in small and in large villages has been almost identical during each decade.

The rapid increase in proportion of the population living in cities (places of 2500 or more people) is a well-known fact, as the decennial Census reports provide official population data for cities. The decline

[17] It is recognized that many places outgrow the classification and go over into the urban class. These data are of value in showing the number of people living in places of a given size at a given time interval, and the trend of population within the classification employed. One can study the growth trends of hamlets and villages only by following the growth of individual towns through a period of time. A procedure for so doing is employed by the writer in his *Growth and Decline of South Dakota Trade Centers, 1901-1933* (Brookings: South Dakota State Agricultural Experiment Station, Bulletin 279, April, 1933), and in his *Washington Farm Trade Centers, 1900-1935*, Part III.

Table 5. Percentage of Total Population of Places with under 2500 People of the United States in Hamlets and Villages by Decades, 1900-30. (For base figures on which percentages are calculated, see Table 4.)

| Year | Hamlets | Small villages | Large villages | Total places |
|---|---|---|---|---|
| 1900 | 21.2 | 39.7 | 39.0 | 100.0 |
| 1910 | 18.9 | 41.2 | 39.8 | 100.0 |
| 1920 | 16.4 | 42.6 | 41.0 | 100.0 |
| 1930 | 14.9 | 42.7 | 42.3 | 100.0 |

Table 6. Percentage of the Total Population of the United States Living in Hamlets and Villages by Decades, and in Open Country and Urban Centers, 1900-30[a]

| Year | Hamlets | Small villages | Large villages | Total places | Cities | Open country |
|---|---|---|---|---|---|---|
| 1900 | 3.9 | 7.2 | 7.1 | 18.2 | 40.0 | 41.8 |
| 1910 | 3.4 | 7.5 | 7.2 | 18.1 | 45.8 | 36.1 |
| 1920 | 2.5 | 6.6 | 6.4 | 15.5 | 51.4 | 33.1 |
| 1930 | 2.0 | 5.9 | 5.8 | 13.7 | 56.2 | 30.1 |

[a]Data in Table 2 and Census data for the Continental United States were employed in arriving at these percentages for hamlets and villages. The percentage living in cities is obtainable from the Census, the remaining population necessarily living in the open country. The open country proportion is, therefore, only an estimate, the degree of accuracy of which depends upon the accuracy of the estimates for hamlets and villages.

Table 7. Percentage of the Rural Population of the United States Living in Hamlets and Villages by Decades, 1900-30[a]

| Year | Hamlets | Small villages | Large villages | Total places |
|---|---|---|---|---|
| 1900 | 6.4 | 12.0 | 11.8 | 30.2 |
| 1910 | 6.3 | 13.8 | 13.3 | 33.4 |
| 1920 | 5.2 | 13.6 | 13.1 | 31.9 |
| 1930 | 4.7 | 13.4 | 13.2 | 31.3 |

[a]Data in Table 4 and Census data for the total rural population (all population living in the open country and places of less than 2500 population) were emoloyed in arriving at these percentages.

Table 8. Percentage of the Rural Non-farm Population of the United States Living in Hamlets and Villages by Decades, 1920-30[a]

| Year | Hamlets | Small villages | Large villages | Total places |
|---|---|---|---|---|
| 1920 | 13.4 | 34.9 | 33.6 | 81.9 |
| 1930 | 10.6 | 30.4 | 30.1 | 71.1 |

[a]Data in Table 4 and Census data for the rural non-farm population were employed in arriving at these percentages.

in proportion of people living in the open country has been consistent, falling from about 42 per cent in 1900 to approximately 30 per cent in 1930. The accuracy of the data for "open country" population presented here depends entirely on the accuracy of the estimated populations for unincorporated places of less than 2500 people, as there are no official population data for the open country.

*Percentage of National Rural Population Living in the Three Groups of Places of under* 2500 *People, 1900-1930* (Table 7). There has been relatively little change in the percentage of the nation's total *rural* population living in places of under 2500 people. In 1900, 30.2 per cent lived in such places; by 1910 the proportion had increased to 33.4 per cent. Since that time the proportion has declined slightly. The percentage of the nation's rural population living in hamlets shows a consistent decrease. The two village groups showed a noticeable increase in their percentage of the total rural population between 1900 and 1910, but since that time they have remained near the 1910 level.

*Percentage of the Total Rural Non-Farm Population of the United States Living in Three Groups of Places of under 2500 People, 1920 and 1930*[18] (Table 8). In 1920, 81.9 per cent of the rural non-farm population lived in places of under 2500 people; in 1930, 71.1 per cent, a decrease of more than 10 per cent. The decrease in the percentage living in all classes of places was marked during the decade, each group losing between three and four per cent of its population.

This table is revealing in that it shows that a very substantial part of the rural non-farm population lives in the open country. Some writers erroneously assume that the rural non-farm population is identical with the village population.[19] This may be a safe assumption for some states, but it is not true for the nation, and certainly it is not true for the states having large industrial groups living in the open country. Without a knowledge of the facts in a given state, it should never be assumed that the two groups are identical. Only about 60 per cent of the rural non-farm population lives in what ordinarily are defined as villages—that is, places with 250-2499 population. This being

[18] The division of the rural population into rural farm and rural non-farm groups is made by the Census for only these two years.

[19] Lane W. Lancaster, *Government in Rural America* (New York: D. Van Nostrand Company, Inc., 1937), pp. 6-9. Lancaster defines a village as having 250-2500 population. According to findings in this paper, only 60 per cent of the non-farm population lives in such villages.

the situation, the statement of the Census that "The rural-nonfarm (or "village") population includes small manufacturing villages and trading centers, unincorporated suburban areas, mining settlements, and so forth, and a considerable number of families living in the open country but not on farms," [20] seems to indicate that the Census overemphasizes somewhat the proportion of the rural non-farm population living in "villages"; in fact, its tendency to identify the two groups seems unjustified.[21]

V. FINDINGS FOR GEOGRAPHICAL DIVISIONS AND FOR STATES

*Number of Places of under 2500 People and their Population by Geographical Divisions and by States.* This section consists largely of tabular materials on the number of incorporated and unincorporated places and the number of people living in these places, classified by major geographical divisions and by states. Only very brief comments are made on tables for geographical divisions, and state tables are presented without comment. It would be interesting to include analyses for geographical divisions and for states based on a series of tables similar to those presented in Part IV for the United States,[22] but space does not permit. The tables presented here give all the basic data needed for such analyses and can readily be used for them and for other purposes by research workers in the respective regions and states. Before using data for any given state, workers should carefully study data for their state in relation to historical facts. Data for some states show extreme fluctuations at certain periods which would suggest that inaccuracies of reporting rather than actual changes may be represented.[23]

*Number of Places and Percentages Incorporated by Geographical Divisions and by States, 1930* (Table 9). Considerable difference as to incorporation exists from state to state and from region to region. New

[20] *Abstract of the Fifteenth Census of the United States* (Washington, D.C., 1933), p. 5.

[21] One must consider the possibility that the present study may not include all "villages" but only those places of enough commercial significance to have at least one mercantile establishment. On the other hand, it does not include the smallest of hamlets, which many would be inclined to omit from the classification of "villages."

[22] A similar analysis has been made of data for the State of Washington. See Paul H. Landis, *Washington Farm Trade Centers, 1900-1935* (Pullman: Washington State Agricultural Experiment Station, Bulletin 360, July, 1938).

[23] As indicated in Part II, such analyses should not be attempted for New England or for states in that geographical division.

Table 9. The Number of Hamlets and Villages and the Number and Percentage Incorporated, Presented according to States and Geographical Divisions as of 1930

| Division and state | Hamlets | | | Small villages | | | Large villages | | | Total places | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total number | incorporated Number | Per cent | Total number | incorporated Number | Per cent | Total number | incorporated Number | Per cent | Total number | incorporated Number | Per cent |
| NEW ENGLAND | 1036 | 16 | 1.5 | 1292 | 44 | 3.4 | 454 | 35 | 7.7 | 2782 | 95 | 3.4 |
| Maine | 446 | 3 | .7 | 410 | 11 | 2.7 | 107 | 8 | 7.5 | 963 | 22 | 2.3 |
| New Hampshire | 176 | — | — | 178 | — | — | 45 | — | — | 399 | — | — |
| Vermont | 161 | 12 | 7.4 | 231 | 29 | 12.6 | 38 | 20 | 52.6 | 430 | 61 | 14.2 |
| Massachusetts | 144 | — | — | 248 | — | — | 160 | — | — | 552 | — | — |
| Rhode Island | 17 | — | — | 44 | — | — | 31 | — | — | 92 | — | — |
| Connecticut | 92 | 1 | 1.1 | 181 | 4 | 2.2 | 73 | 7 | 9.6 | 346 | 12 | 3.5 |
| MIDDLE ATLANTIC | 4099 | 138 | 3.4 | 2330 | 627 | 26.9 | 786 | 447 | 56.9 | 7215 | 1212 | 16.8 |
| New York | 1476 | 23 | 1.6 | 910 | 231 | 25.4 | 257 | 146 | 56.8 | 2643 | 400 | 15.1 |
| New Jersey | 332 | 19 | 5.7 | 241 | 67 | 27.8 | 132 | 85 | 64.4 | 705 | 171 | 24.3 |
| Pennsylvania | 2291 | 96 | 4.2 | 1179 | 329 | 27.9 | 397 | 216 | 54.4 | 3867 | 641 | 16.6 |
| EAST NORTH CENTRAL | 5649 | 454 | 8.0 | 2790 | 1713 | 61.4 | 750 | 666 | 88.8 | 9189 | 2833 | 30.8 |
| Ohio | 1547 | 138 | 8.9 | 698 | 390 | 55.9 | 182 | 160 | 87.9 | 2427 | 688 | 28.3 |
| Indiana | 995 | 70 | 7.0 | 501 | 261 | 52.1 | 111 | 97 | 87.4 | 1607 | 428 | 26.6 |
| Illinois | 1196 | 162 | 13.5 | 698 | 564 | 80.8 | 216 | 211 | 97.7 | 2110 | 937 | 44.4 |
| Michigan | 896 | 31 | 3.5 | 452 | 219 | 48.5 | 140 | 111 | 79.3 | 1488 | 361 | 24.3 |
| Wisconsin | 1015 | 53 | 5.2 | 441 | 279 | 63.3 | 101 | 87 | 86.1 | 1557 | 419 | 26.9 |
| WEST NORTH CENTRAL | 6102 | 1176 | 19.3 | 2321 | 2065 | 89.0 | 587 | 560 | 95.4 | 9010 | 3801 | 42.2 |
| Minnesota | 1034 | 223 | 21.6 | 371 | 339 | 91.4 | 97 | 93 | 95.9 | 1502 | 655 | 43.6 |
| Iowa | 898 | 244 | 27.2 | 514 | 469 | 91.2 | 128 | 123 | 96.1 | 1540 | 836 | 54.3 |
| Missouri | 1953 | 238 | 12.2 | 448 | 347 | 77.5 | 129 | 116 | 89.9 | 2530 | 701 | 27.7 |
| North Dakota | 503 | 113 | 22.5 | 193 | 172 | 89.1 | 29 | 29 | 100.0 | 725 | 314 | 43.3 |
| South Dakota | 457 | 87 | 19.0 | 164 | 155 | 94.5 | 41 | 41 | 100.0 | 662 | 283 | 42.7 |
| Nebraska | 467 | 149 | 31.9 | 276 | 272 | 98.6 | 75 | 73 | 97.3 | 818 | 494 | 60.4 |
| Kansas | 790 | 122 | 15.4 | 355 | 311 | 87.6 | 88 | 85 | 96.6 | 1233 | 518 | 42.0 |
| SOUTH ATLANTIC | 6608 | 498 | 7.5 | 1881 | 991 | 52.7 | 563 | 428 | 76.0 | 9052 | 1917 | 21.2 |
| Delaware | 73 | 13 | 17.8 | 36 | 24 | 66.7 | 11 | 10 | 90.9 | 120 | 47 | 39.2 |
| Maryland | 703 | 27 | 3.8 | 196 | 63 | 32.1 | 45 | 26 | 57.8 | 944 | 116 | 12.3 |
| Virginia | 1781 | 22 | 1.2 | 265 | 106 | 40.0 | 67 | 42 | 62.7 | 2113 | 170 | 8.0 |
| West Virginia | 1347 | 18 | 1.3 | 368 | 89 | 24.3 | 100 | 62 | 62.0 | 1815 | 169 | 9.3 |
| North Carolina | 1055 | 122 | 11.6 | 311 | 217 | 69.8 | 109 | 91 | 83.5 | 1475 | 430 | 29.2 |
| South Carolina | 437 | 72 | 16.5 | 140 | 99 | 70.7 | 70 | 54 | 77.1 | 647 | 225 | 34.8 |
| Georgia | 766 | 177 | 23.1 | 334 | 261 | 78.1 | 98 | 91 | 92.9 | 1198 | 529 | 44.2 |
| Florida | 446 | 47 | 10.5 | 231 | 132 | 57.1 | 63 | 52 | 82.5 | 740 | 231 | 31.2 |
| EAST SOUTH CENTRAL | 5091 | 236 | 4.6 | 1090 | 540 | 49.5 | 327 | 242 | 74.0 | 6508 | 1018 | 15.6 |
| Kentucky | 2632 | 85 | 3.2 | 342 | 157 | 45.9 | 103 | 74 | 71.8 | 3077 | 316 | 10.3 |
| Tennessee | 946 | 36 | 3.8 | 234 | 100 | 42.7 | 61 | 49 | 80.3 | 1241 | 185 | 14.9 |
| Alabama | 729 | 46 | 6.3 | 293 | 133 | 45.4 | 102 | 64 | 62.7 | 1124 | 243 | 21.6 |
| Mississippi | 784 | 69 | 8.8 | 221 | 150 | 67.9 | 61 | 55 | 90.2 | 1066 | 274 | 25.7 |
| WEST SOUTH CENTRAL | 4219 | 220 | 5.2 | 1699 | 752 | 44.3 | 498 | 396 | 79.5 | 6416 | 1368 | 21.0 |
| Arkansas | 1080 | 98 | 9.1 | 287 | 185 | 64.5 | 62 | 57 | 91.9 | 1429 | 340 | 23.8 |
| Louisiana | 644 | 10 | 1.6 | 261 | 100 | 38.3 | 76 | 52 | 68.4 | 981 | 162 | 16.5 |
| Oklahoma | 710 | 102 | 14.4 | 322 | 245 | 76.1 | 105 | 98 | 93.3 | 1137 | 445 | 39.1 |
| Texas | 1785 | 10 | .6 | 829 | 222 | 26.8 | 255 | 189 | 74.1 | 2869 | 421 | 14.7 |
| MOUNTAIN | 2234 | 150 | 6.7 | 846 | 396 | 46.7 | 222 | 164 | 73.9 | 3302 | 710 | 21.5 |
| Montana | 472 | 8 | 1.7 | 117 | 66 | 56.4 | 26 | 24 | 92.3 | 615 | 98 | 15.9 |
| Idaho | 285 | 30 | 10.5 | 149 | 77 | 51.7 | 23 | 22 | 95.7 | 457 | 129 | 28.2 |
| Wyoming | 207 | 28 | 13.5 | 47 | 31 | 66.0 | 22 | 17 | 77.3 | 276 | 76 | 27.5 |
| Colorado | 543 | 68 | 12.5 | 153 | 104 | 68.0 | 47 | 42 | 89.4 | 743 | 214 | 28.8 |
| New Mexico | 342 | 4 | 1.2 | 119 | 25 | 21.0 | 25 | 11 | 44.0 | 486 | 40 | 8.2 |
| Arizona | 164 | — | — | 67 | 11 | 16.4 | 21 | 9 | 42.9 | 252 | 20 | 7.9 |
| Utah | 130 | 9 | 6.9 | 154 | 79 | 51.3 | 42 | 34 | 81.0 | 326 | 122 | 37.4 |
| Nevada | 91 | 3 | 3.3 | 40 | 3 | 7.5 | 16 | 5 | 31.2 | 147 | 11 | 7.5 |
| PACIFIC | 2165 | 94 | 4.3 | 722 | 242 | 33.5 | 214 | 148 | 69.2 | 3101 | 484 | 15.6 |
| Washington | 653 | 26 | 4.0 | 255 | 115 | 45.1 | 48 | 42 | 87.5 | 956 | 183 | 19.1 |
| Oregon | 595 | 62 | 10.4 | 107 | 85 | 79.4 | 33 | 29 | 87.9 | 735 | 176 | 23.9 |
| California | 917 | 6 | .7 | 360 | 42 | 11.7 | 133 | 77 | 57.9 | 1410 | 125 | 8.9 |
| TOTAL | 37,203 | 2982 | 8.0 | 14,971 | 7370 | 49.2 | 4401 | 3086 | 70.1 | 56,575 | 13,438 | 23.8 |

England has very few places of any class of hamlets or villages incorporated, and three states in that division (New Hampshire, Massachusetts, and Rhode Island) do not incorporate small places at all. Virginia, West Virginia, and Maryland in the South Atlantic division have a small percentage incorporated. The same is true of New Mexico, Arizona, and Nevada in the Mountain states and California in the Pacific states. The West North Central states have the highest percentage of places incorporated; the East North Central states, the second highest. Nebraska has more of its places of fewer than 2500 people incorporated than any other state.

In all geographical divisions, the larger the place the greater is the likelihood of incorporation, comparatively few places of under 250 people being incorporated.

*A Summary of the Number of Places Incorporated by Size, Number and Percentage for Geographical Divisions for the Decades, 1900-1930* (Table 10). In all geographical sections the number of hamlets has shown a marked decline. In some divisions they had reached their climax by 1900, in others, by 1910, but in all divisions they have declined since 1910. The most extreme decline has been in the South Atlantic division, where there were 13,277 such places in 1900 but only 6608 in 1930. In most regions, the number of hamlets declined one-fourth to one-third. This does not necessarily mean that all of these hamlets have disappeared. Some of them may have grown into the next higher group, but most of them probably have disappeared, at least as places of trade. We are living in an age in which the hamlet is not so essential as when the wagon haul determined the limits of a farmer's movement.

The number of small villages has changed very little in recent decades. Only in the West South Central and Mountain states did they show any considerable increase between 1920 and 1930. The number of places in the two larger groups has remained about constant in all divisions. This fact, in the face of the national population increase, suggests that the period of town building in America is past.

Incorporation trends may be summarized as follows:

1. All divisions show an increase in the percentage of hamlets incorporated.
2. Except the Pacific states most divisions shown an increase in the percentage of small villages incorporated.

Table 10. A Summary of the Number of Hamlets and Villages and of the Number and Percentages Incorporated, Grouped according to Geographical Divisions by Decades, 1900-30.

| Division and year | Hamlets Total number | Hamlets incorporated Number | Hamlets incorporated Per cent | Small villages Total number | Small villages incorporated Number | Small villages incorporated Per cent | Large villages Total number | Large villages incorporated Number | Large villages incorporated Per cent | Total places Total number | Total places incorporated Number | Total places incorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **New England:** | | | | | | | | | | | | |
| 1900 | 1052 | 4 | .4 | 1058 | 27 | 2.6 | 461 | 40 | 8.7 | 2571 | 71 | 2.8 |
| 1910 | 1588 | 8 | .5 | 1489 | 33 | 2.2 | 453 | 34 | 7.5 | 3530 | 75 | 2.1 |
| 1920 | 1184 | 13 | 1.1 | 1336 | 38 | 2.8 | 446 | 32 | 7.2 | 2966 | 83 | 2.8 |
| 1930 | 1036 | 16 | 1.5 | 1292 | 44 | 3.4 | 454 | 35 | 7.7 | 2782 | 95 | 3.4 |
| **Middle Atlantic:** | | | | | | | | | | | | |
| 1900 | 6719 | 116 | 1.7 | 2368 | 592 | 25.0 | 737 | 376 | 51.0 | 9824 | 1084 | 11.0 |
| 1910 | 5810 | 119 | 2.0 | 2451 | 613 | 25.0 | 797 | 441 | 55.3 | 9058 | 1173 | 12.9 |
| 1920 | 4857 | 144 | 3.0 | 2359 | 577 | 24.5 | 782 | 432 | 55.2 | 7998 | 1153 | 14.4 |
| 1930 | 4099 | 138 | 3.4 | 2330 | 627 | 26.9 | 786 | 447 | 56.9 | 7215 | 1212 | 16.8 |
| **East North Central:** | | | | | | | | | | | | |
| 1900 | 8886 | 203 | 2.3 | 2691 | 1420 | 52.8 | 733 | 590 | 80.5 | 12,310 | 2213 | 18.0 |
| 1910 | 7478 | 301 | 4.0 | 2918 | 1657 | 56.8 | 750 | 652 | 86.9 | 11,146 | 2610 | 23.4 |
| 1920 | 6503 | 376 | 5.8 | 2799 | 1656 | 59.2 | 751 | 361 | 88.0 | 10,053 | 2693 | 26.8 |
| 1930 | 5649 | 454 | 8.0 | 2790 | 1713 | 61.4 | 750 | 366 | 88.8 | 9189 | 2833 | 30.8 |
| **East South Central:** | | | | | | | | | | | | |
| 1900 | 9292 | 237 | 2.6 | 850 | 376 | 44.2 | 185 | 137 | 74.1 | 10,327 | 750 | 7.3 |
| 1910 | 9049 | 306 | 3.4 | 1068 | 543 | 50.8 | 251 | 210 | 83.7 | 10,368 | 1059 | 10.2 |
| 1920 | 6453 | 209 | 3.2 | 1096 | 539 | 49.2 | 262 | 214 | 81.7 | 7811 | 962 | 12.3 |
| 1930 | 5091 | 236 | 4.6 | 1090 | 540 | 49.5 | 327 | 232 | 74.0 | 6508 | 1018 | 15.6 |
| **West South Central:** | | | | | | | | | | | | |
| 1900 | 5631 | 71 | 1.3 | 922 | 280 | 30.4 | 226 | 154 | 68.1 | 6779 | 505 | 7.4 |
| 1910 | 6885 | 146 | 2.1 | 1458 | 566 | 38.8 | 386 | 286 | 74.1 | 8729 | 998 | 11.4 |
| 1920 | 5156 | 154 | 3.0 | 1594 | 670 | 42.0 | 460 | 363 | 78.9 | 7210 | 1187 | 16.5 |
| 1930 | 4219 | 220 | 5.2 | 1699 | 752 | 44.3 | 498 | 396 | 79.5 | 6416 | 1368 | 21.0 |
| **Mountain:** | | | | | | | | | | | | |
| 1900 | 2478 | 47 | 1.9 | 470 | 142 | 30.2 | 120 | 72 | 60.0 | 3068 | 261 | 8.5 |
| 1910 | 3139 | 90 | 2.9 | 724 | 275 | 38.0 | 171 | 108 | 63.2 | 4034 | 473 | 11.7 |
| 1920 | 2469 | 106 | 4.3 | 729 | 358 | 49.1 | 227 | 171 | 75.3 | 3425 | 635 | 18.5 |
| 1930 | 2234 | 150 | 6.7 | 846 | 396 | 46.7 | 222 | 164 | 73.9 | 3302 | 710 | 21.5 |
| **West North Central:** | | | | | | | | | | | | |
| 1900 | 8194 | 502 | 6.1 | 1928 | 1415 | 73.4 | 485 | 444 | 91.5 | 10,607 | 2361 | 22.3 |
| 1910 | 7768 | 855 | 11.0 | 2235 | 1871 | 83.7 | 540 | 511 | 94.6 | 10,543 | 3237 | 30.7 |
| 1920 | 6501 | 940 | 14.5 | 2400 | 2053 | 85.5 | 598 | 572 | 95.7 | 9499 | 3565 | 37.5 |
| 1930 | 6102 | 1176 | 19.3 | 2321 | 2065 | 89.0 | 587 | 560 | 95.4 | 9010 | 3801 | 42.2 |
| **South Atlantic:** | | | | | | | | | | | | |
| 1900 | 13,277 | 360 | 2.7 | 1384 | 665 | 48.0 | 296 | 208 | 70.3 | 14,957 | 1233 | 8.2 |
| 1910 | 12,009 | 519 | 4.3 | 1714 | 907 | 52.9 | 450 | 337 | 74.9 | 14,173 | 1763 | 12.4 |
| 1920 | 8257 | 413 | 5.0 | 1802 | 957 | 52.0 | 515 | 387 | 75.1 | 10,554 | 1737 | 16.5 |
| 1930 | 6608 | 498 | 7.5 | 1881 | 991 | 52.7 | 563 | 428 | 76.0 | 9052 | 1917 | 21.2 |
| **Pacific:** | | | | | | | | | | | | |
| 1900 | 2874 | 68 | 2.4 | 459 | 140 | 30.5 | 106 | 69 | 65.1 | 3439 | 277 | 8.1 |
| 1910 | 3111 | 57 | 1.8 | 571 | 236 | 41.7 | 173 | 136 | 78.6 | 3855 | 431 | 11.2 |
| 1920 | 2324 | 81 | 3.5 | 723 | 255 | 35.3 | 205 | 151 | 73.7 | 3252 | 487 | 15.0 |
| 1930 | 2165 | 94 | 4.3 | 722 | 242 | 33.5 | 214 | 148 | 69.2 | 3101 | 484 | 15.6 |

3. In most divisions the percentage of large villages incorporated has decreased.

A statistical summary of the number and class of places by states and of the number and percentage incorporated is presented (Table 11). In order to save space comments are omitted, but this will not limit the usefulness of the data to the research worker.

*Number and Percentage of the Population of Places with Fewer than 2500 People Living in Unincorporated Places in the Nine Geographical Divisions, 1930* (Table 12). In the nation, 80.7 per cent of the hamlet population lives in unincorporated centers, 46 per cent of the small-village population, 32.3 per cent of the large-village population, and 45.4 per cent of all people in all places of under 2500 population. This means that this 45.4 per cent is not counted in the population of incorporated areas reported in the Census but is included for the most part in the rural non-farm group.

In New England most of the population of places with under 2500 people is in unincorporated territory (94.5 per cent). At the other extreme in the West North Central section, only 14.8 per cent is in unincorporated territory, which is the lowest percentage of any region. In this area incorporation is most frequently found, only 52.6 per cent of its hamlet population being in unincorporated territory. In all other regions 80 or more per cent of the hamlet population lives in unincorporated places. The percentage of small-village population in unincorporated places ranges from 8.8 per cent in the West North Central states to 96.4 per cent in New England, and the percentage of large-village population ranges from 4.9 per cent in the West North Central region to 92 per cent in New England. The condition in the East North Central section with 12.4 per cent in unincorporated places approaches nearest that in the West North Central. The percentage in other sections approaches the average for the nation.

*Distribution of Population of Places with under 2500 People by Number and Percentage in Incorporated Territory by Geographical Divisions by Decades, 1900-1930* (Table 13). New England states: Most of the hamlet population was living in unincorporated places in 1930 but slightly less than at other periods. About 97 per cent of the small-village population has lived in unincorporated places during the 30 years. A smaller proportion of the population in the 0-2499 classification was living in unincorporated places in 1930 than in 1910 or 1920.

Table 11. A Summary of the Number of Hamlets and Villages and of the Number and Percentages Incorporated, Compiled according to States by Decades, 1900-30[a].

| State and year | Hamlets Total number | Hamlets incorporated Number | Hamlets incorporated Per cent | Small villages Total number | Small villages incorporated Number | Small villages incorporated Per cent | Large villages Total number | Large villages incorporated Number | Large villages incorporated Per cent | Total places Total number | Total places incorporated Number | Total places incorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW ENGLAND | | | | | | | | | | | | |
| Maine | | | | | | | | | | | | |
| 1900 | 695 | — | — | 468 | 9 | 1.9 | 84 | 13 | 15.4 | 1247 | 22 | 1.8 |
| 1910 | 644 | 1 | .2 | 442 | 8 | 1.8 | 112 | 8 | 7.1 | 1198 | 17 | 1.4 |
| 1920 | 472 | 2 | .4 | 403 | 8 | 2.0 | 114 | 8 | 7.0 | 989 | 18 | 1.8 |
| 1930 | 446 | 3 | .7 | 410 | 11 | 2.7 | 107 | 8 | 7.5 | 963 | 22 | 2.3 |
| New Hampshire | | | | | | | | | | | | |
| 1900 | 42 | — | — | 100 | — | — | 77 | — | — | 219 | — | — |
| 1910 | 247 | — | — | 204 | — | — | 52 | — | — | 503 | — | — |
| 1920 | 186 | — | — | 188 | — | — | 47 | — | — | 421 | — | — |
| 1930 | 176 | — | — | 178 | — | — | 45 | — | — | 399 | — | — |
| Vermont | | | | | | | | | | | | |
| 1900 | 42 | 3 | 7.1 | 119 | 16 | 13.4 | 93 | 19 | 20.4 | 254 | 38 | 15.0 |
| 1910 | 223 | 5 | 2.2 | 257 | 21 | 8.2 | 50 | 21 | 42.0 | 530 | 47 | 8.9 |
| 1920 | 178 | 9 | 5.1 | 228 | 26 | 11.4 | 39 | 20 | 51.3 | 445 | 55 | 12.4 |
| 1930 | 161 | 12 | 7.4 | 231 | 29 | 12.6 | 38 | 20 | 52.6 | 430 | 61 | 14.2 |
| Massachusetts | | | | | | | | | | | | |
| 1900 | 37 | — | — | 88 | — | — | 110 | — | — | 235 | — | — |
| 1910 | 287 | — | — | 293 | — | — | 145 | — | — | 725 | — | — |
| 1920 | 211 | — | — | 266 | — | — | 150 | — | — | 627 | — | — |
| 1930 | 144 | — | — | 248 | — | — | 160 | — | — | 552 | — | — |
| Rhode Island | | | | | | | | | | | | |
| 1900 | 59 | — | — | 59 | — | — | 21 | — | — | 139 | — | — |
| 1910 | 39 | — | — | 62 | — | — | 25 | — | — | 126 | — | — |
| 1920 | 27 | — | — | 57 | — | — | 27 | — | — | 111 | — | — |
| 1930 | 17 | — | — | 44 | — | — | 31 | — | — | 92 | — | — |
| Connecticut | | | | | | | | | | | | |
| 1900 | 177 | 1 | .6 | 224 | 2 | .9 | 76 | 8 | 10.5 | 477 | 11 | 2.3 |
| 1910 | 148 | 2 | 1.4 | 231 | 4 | 1.7 | 69 | 5 | 7.2 | 448 | 11 | 2.5 |
| 1920 | 110 | 2 | 1.8 | 194 | 4 | 2.1 | 69 | 4 | 5.8 | 373 | 10 | 2.7 |
| 1930 | 92 | 1 | 1.1 | 181 | 4 | 2.2 | 73 | 7 | 9.6 | 346 | 12 | 3.5 |
| MIDDLE ATLANTIC | | | | | | | | | | | | |
| New York | | | | | | | | | | | | |
| 1900 | 2349 | 4 | .2 | 914 | 186 | 20.4 | 352 | 143 | 40.6 | 3615 | 333 | 9.2 |
| 1910 | 2084 | 9 | .4 | 926 | 192 | 20.7 | 321 | 150 | 46.7 | 3331 | 351 | 10.5 |
| 1920 | 1696 | 16 | .9 | 892 | 192 | 21.5 | 290 | 143 | 49.3 | 2878 | 351 | 12.2 |
| 1930 | 1476 | 23 | 1.6 | 910 | 231 | 25.4 | 257 | 146 | 56.8 | 2643 | 400 | 15.1 |
| New Jersey | | | | | | | | | | | | |
| 1900 | 535 | 19 | 3.6 | 298 | 60 | 20.1 | 95 | 44 | 46.3 | 928 | 123 | 13.3 |
| 1910 | 468 | 16 | 3.4 | 303 | 74 | 24.4 | 103 | 64 | 62.1 | 874 | 154 | 17.6 |
| 1920 | 418 | 24 | 5.7 | 271 | 66 | 24.4 | 103 | 64 | 62.1 | 792 | 154 | 19.4 |
| 1930 | 332 | 19 | 5.7 | 241 | 67 | 27.8 | 132 | 85 | 64.4 | 705 | 171 | 24.3 |
| Pennsylvania | | | | | | | | | | | | |
| 1900 | 3835 | 93 | 2.4 | 1156 | 346 | 29.9 | 290 | 189 | 65.2 | 5281 | 628 | 11.9 |
| 1910 | 3258 | 94 | 2.9 | 1222 | 347 | 28.4 | 373 | 227 | 60.9 | 4853 | 668 | 13.8 |
| 1920 | 2743 | 104 | 3.8 | 1196 | 319 | 26.7 | 389 | 225 | 57.8 | 4328 | 648 | 15.0 |
| 1930 | 2291 | 96 | 4.2 | 1179 | 329 | 27.9 | 397 | 216 | 54.4 | 3867 | 641 | 16.6 |
| EAST NORTH CENTRAL | | | | | | | | | | | | |
| Ohio | | | | | | | | | | | | |
| 1900 | 2455 | 81 | 3.3 | 775 | 368 | 47.5 | 157 | 132 | 84.1 | 3387 | 581 | 17.2 |
| 1910 | 1954 | 105 | 5.4 | 769 | 392 | 51.0 | 170 | 147 | 86.5 | 2893 | 644 | 22.3 |
| 1920 | 1734 | 125 | 7.2 | 740 | 385 | 52.0 | 169 | 152 | 89.9 | 2643 | 662 | 25.0 |
| 1930 | 1547 | 138 | 8.9 | 698 | 390 | 55.9 | 182 | 160 | 87.9 | 2427 | 688 | 28.3 |
| Indiana | | | | | | | | | | | | |
| 1900 | 1655 | 33 | 2.0 | 486 | 189 | 38.9 | 100 | 92 | 92.0 | 2241 | 314 | 14.0 |
| 1910 | 1439 | 49 | 3.4 | 500 | 227 | 45.4 | 119 | 107 | 89.9 | 2058 | 383 | 18.6 |
| 1920 | 1169 | 50 | 4.3 | 496 | 237 | 47.8 | 115 | 101 | 87.8 | 1780 | 388 | 21.8 |
| 1930 | 995 | 70 | 7.0 | 501 | 261 | 52.1 | 111 | 97 | 87.4 | 1607 | 428 | 26.6 |
| Illinois | | | | | | | | | | | | |
| 1900 | 1740 | 76 | 4.4 | 672 | 534 | 79.5 | 213 | 199 | 93.4 | 2625 | 809 | 30.8 |
| 1910 | 1504 | 115 | 7.6 | 716 | 585 | 81.7 | 232 | 222 | 95.7 | 2452 | 922 | 37.6 |
| 1920 | 1354 | 129 | 9.7 | 695 | 567 | 81.6 | 238 | 226 | 95.0 | 2267 | 922 | 40.7 |
| 1930 | 1196 | 162 | 13.5 | 698 | 564 | 80.8 | 216 | 211 | 97.7 | 2110 | 937 | 44.4 |
| Michigan | | | | | | | | | | | | |
| 1900 | 1545 | 10 | .6 | 435 | 194 | 44.6 | 163 | 105 | 64.4 | 2143 | 309 | 14.4 |
| 1910 | 1291 | 22 | 1.7 | 495 | 228 | 46.1 | 141 | 107 | 75.9 | 1927 | 357 | 18.5 |
| 1920 | 1133 | 32 | 2.8 | 443 | 216 | 48.8 | 129 | 102 | 79.1 | 1705 | 350 | 20.5 |
| 1930 | 896 | 31 | 3.5 | 452 | 219 | 48.5 | 140 | 111 | 79.3 | 1488 | 361 | 24.3 |

Table 11 Continued.

| State and year | Hamlets Total number | Hamlets incorporated Number | Hamlets incorporated Per cent | Small villages Total number | Small villages incorporated Number | Small villages incorporated Per cent | Large villages Total number | Large villages incorporated Number | Large villages incorporated Per cent | Total places Total number | Total places incorporated Number | Total places incorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wisconsin | | | | | | | | | | | | |
| 1900 | 1491 | 3 | .2 | 323 | 135 | 41.8 | 100 | 62 | 62.0 | 1914 | 200 | 10.4 |
| 1910 | 1290 | 10 | .8 | 438 | 225 | 51.4 | 88 | 69 | 78.4 | 1816 | 304 | 16.7 |
| 1920 | 1133 | 40 | 3.5 | 425 | 252 | 59.3 | 100 | 80 | 80.0 | 1658 | 372 | 22.4 |
| 1930 | 1015 | 53 | 5.2 | 441 | 279 | 63.3 | 101 | 87 | 86.1 | 1557 | 419 | 26.9 |
| WEST NORTH CENTRAL | | | | | | | | | | | | |
| Minnesota | | | | | | | | | | | | |
| 1900 | 1311 | 98 | 7.5 | 264 | 225 | 85.2 | 97 | 85 | 87.6 | 1672 | 408 | 24.4 |
| 1910 | 1318 | 208 | 15.8 | 330 | 293 | 88.8 | 96 | 95 | 99.0 | 1744 | 596 | 34.2 |
| 1920 | 1088 | 177 | 18.3 | 387 | 341 | 88.1 | 109 | 105 | 96.3 | 1584 | 623 | 39.3 |
| 1930 | 1034 | 223 | 21.6 | 371 | 339 | 91.4 | 97 | 93 | 95.9 | 1502 | 655 | 43.6 |
| Iowa | | | | | | | | | | | | |
| 1900 | 1240 | 95 | 7.7 | 526 | 399 | 75.9 | 132 | 116 | 87.9 | 1898 | 610 | 32.1 |
| 1910 | 1052 | 202 | 19.2 | 527 | 452 | 85.8 | 122 | 114 | 93.4 | 1701 | 768 | 45.1 |
| 1920 | 960 | 221 | 23.0 | 534 | 472 | 88.4 | 131 | 127 | 96.9 | 1625 | 820 | 50.5 |
| 1930 | 898 | 244 | 27.2 | 514 | 469 | 91.2 | 128 | 123 | 96.1 | 1540 | 836 | 54.3 |
| Missouri | | | | | | | | | | | | |
| 1900 | 2444 | 129 | 5.3 | 375 | 259 | 69.1 | 104 | 99 | 95.2 | 2923 | 487 | 16.7 |
| 1910 | 2356 | 173 | 7.3 | 470 | 326 | 69.4 | 118 | 104 | 88.1 | 2944 | 603 | 20.5 |
| 1920 | 2123 | 168 | 7.9 | 485 | 356 | 73.4 | 121 | 114 | 94.2 | 2729 | 638 | 23.4 |
| 1930 | 1953 | 238 | 12.2 | 448 | 347 | 77.5 | 129 | 116 | 89.9 | 2530 | 701 | 27.7 |
| North Dakota | | | | | | | | | | | | |
| 1900 | 535 | 10 | 1.9 | 159 | 46 | 28.9 | 15 | 15 | 100.0 | 709 | 71 | 10.0 |
| 1910 | 763 | 59 | 7.7 | 146 | 120 | 82.2 | 23 | 23 | 100.0 | 932 | 202 | 21.7 |
| 1920 | 555 | 87 | 15.7 | 203 | 166 | 81.8 | 29 | 29 | 100.0 | 787 | 282 | 35.8 |
| 1930 | 503 | 113 | 22.5 | 193 | 172 | 89.1 | 29 | 29 | 100.0 | 725 | 314 | 43.3 |
| South Dakota | | | | | | | | | | | | |
| 1900 | 591 | 45 | 7.6 | 78 | 68 | 87.2 | 17 | 16 | 94.1 | 686 | 129 | 18.8 |
| 1910 | 575 | 58 | 10.1 | 145 | 132 | 91.0 | 32 | 32 | 100.0 | 752 | 222 | 29.5 |
| 1920 | 484 | 73 | 15.1 | 156 | 148 | 94.9 | 42 | 40 | 95.2 | 682 | 261 | 38.3 |
| 1930 | 457 | 87 | 19.0 | 164 | 155 | 94.5 | 41 | 41 | 100.0 | 662 | 283 | 42.7 |
| Nebraska | | | | | | | | | | | | |
| 1900 | 803 | 78 | 9.7 | 233 | 224 | 96.1 | 48 | 44 | 91.7 | 1084 | 346 | 31.9 |
| 1910 | 731 | 97 | 13.3 | 274 | 266 | 97.1 | 65 | 64 | 98.5 | 1070 | 427 | 39.9 |
| 1920 | 487 | 126 | 25.9 | 286 | 277 | 96.9 | 78 | 76 | 97.4 | 851 | 479 | 56.3 |
| 1930 | 467 | 149 | 31.9 | 276 | 272 | 98.6 | 75 | 73 | 97.3 | 818 | 494 | 60.4 |
| Kansas | | | | | | | | | | | | |
| 1900 | 1270 | 47 | 3.7 | 293 | 194 | 66.2 | 72 | 69 | 95.8 | 1635 | 310 | 19.0 |
| 1910 | 973 | 58 | 6.0 | 343 | 282 | 82.2 | 84 | 79 | 94.0 | 1400 | 419 | 29.9 |
| 1920 | 804 | 88 | 10.9 | 349 | 293 | 84.0 | 88 | 81 | 92.0 | 1241 | 462 | 37.2 |
| 1930 | 790 | 122 | 15.4 | 355 | 311 | 87.6 | 88 | 85 | 96.6 | 1233 | 518 | 42.0 |
| SOUTH ATLANTIC | | | | | | | | | | | | |
| Delaware | | | | | | | | | | | | |
| 1900 | 126 | 5 | 4.0 | 40 | 17 | 42.5 | 9 | 9 | 100.0 | 175 | 31 | 17.7 |
| 1910 | 109 | 9 | 8.3 | 41 | 23 | 56.1 | 10 | 10 | 100.0 | 160 | 42 | 26.3 |
| 1920 | 93 | 14 | 15.1 | 38 | 24 | 63.2 | 9 | 9 | 100.0 | 140 | 47 | 33.6 |
| 1930 | 73 | 13 | 17.8 | 36 | 24 | 66.7 | 11 | 10 | 90.9 | 120 | 47 | 39.2 |
| Maryland | | | | | | | | | | | | |
| 1900 | 933 | 17 | 1.8 | 145 | 49 | 33.8 | 38 | 18 | 47.4 | 1116 | 84 | 7.5 |
| 1910 | 1006 | 18 | 1.8 | 177 | 58 | 32.8 | 52 | 24 | 46.2 | 1235 | 100 | 8.1 |
| 1920 | 862 | 21 | 2.4 | 181 | 55 | 30.4 | 43 | 25 | 58.1 | 1086 | 101 | 9.3 |
| 1930 | 703 | 27 | 3.8 | 196 | 63 | 32.1 | 45 | 26 | 57.8 | 944 | 116 | 12.3 |
| Virginia | | | | | | | | | | | | |
| 1900 | 3246 | 24 | .7 | 190 | 71 | 37.4 | 44 | 30 | 68.2 | 3480 | 125 | 3.6 |
| 1910 | 3126 | 28 | .9 | 239 | 91 | 38.1 | 59 | 40 | 67.8 | 3424 | 159 | 4.6 |
| 1920 | 2139 | 20 | .9 | 241 | 96 | 39.8 | 65 | 44 | 67.7 | 2445 | 160 | 6.5 |
| 1930 | 1781 | 22 | 1.2 | 265 | 106 | 40.0 | 67 | 42 | 62.7 | 2113 | 170 | 8.0 |
| West Virginia | | | | | | | | | | | | |
| 1900 | 1711 | 24 | 1.4 | 212 | 69 | 32.5 | 40 | 20 | 50.0 | 1963 | 113 | 5.8 |
| 1910 | 2160 | 38 | 1.8 | 316 | 100 | 31.6 | 68 | 46 | 67.6 | 2544 | 184 | 7.2 |
| 1920 | 1594 | 17 | 1.1 | 328 | 89 | 26.3 | 80 | 49 | 61.3 | 2012 | 155 | 7.7 |
| 1930 | 1347 | 18 | 1.3 | 368 | 89 | 24.2 | 100 | 62 | 62.0 | 1815 | 169 | 9.3 |
| North Carolina | | | | | | | | | | | | |
| 1900 | 2792 | 118 | 4.2 | 204 | 146 | 71.6 | 46 | 36 | 78.3 | 3042 | 300 | 9.9 |
| 1910 | 2236 | 154 | 6.9 | 274 | 201 | 73.4 | 71 | 59 | 83.1 | 2581 | 414 | 16.0 |
| 1920 | 1334 | 121 | 9.1 | 285 | 202 | 70.9 | 104 | 80 | 76.9 | 1723 | 403 | 23.4 |
| 1930 | 1055 | 122 | 11.6 | 311 | 217 | 69.8 | 109 | 91 | 83.5 | 1475 | 430 | 29.2 |

Table 11 Continued.

| State and year | Hamlets: Total number | Hamlets incorporated: Number | Hamlets incorporated: Per cent | Small villages: Total number | Small villages incorporated: Number | Small villages incorporated: Per cent | Large villages: Total number | Large villages incorporated: Number | Large villages incorporated: Per cent | Total places: Total number | Total places incorporated: Number | Total places incorporated: Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Carolina | | | | | | | | | | | | |
| 1900 | 1193 | 69 | 5.8 | 132 | 80 | 60.6 | 41 | 25 | 61.0 | 1366 | 174 | 12.7 |
| 1910 | 960 | 81 | 8.4 | 142 | 99 | 69.7 | 62 | 43 | 69.4 | 1164 | 223 | 19.2 |
| 1920 | 591 | 71 | 12.0 | 145 | 102 | 70.3 | 65 | 50 | 76.9 | 801 | 223 | 27.8 |
| 1930 | 437 | 72 | 16.5 | 140 | 99 | 70.7 | 70 | 54 | 77.1 | 647 | 225 | 34.8 |
| Georgia | | | | | | | | | | | | |
| 1900 | 2343 | 84 | 3.6 | 303 | 191 | 63.0 | 59 | 55 | 93.2 | 2705 | 330 | 12.2 |
| 1910 | 1545 | 172 | 11.1 | 341 | 259 | 76.0 | 92 | 85 | 92.4 | 1978 | 516 | 26.1 |
| 1920 | 1032 | 133 | 12.9 | 356 | 273 | 76.7 | 94 | 86 | 91.5 | 1482 | 492 | 33.2 |
| 1930 | 766 | 177 | 23.1 | 334 | 261 | 78.1 | 98 | 91 | 92.9 | 1198 | 529 | 44.2 |
| Florida | | | | | | | | | | | | |
| 1900 | 933 | 19 | 2.0 | 158 | 42 | 26.6 | 19 | 15 | 78.9 | 1110 | 76 | 6.8 |
| 1910 | 867 | 19 | 2.2 | 184 | 76 | 41.3 | 36 | 30 | 83.3 | 1087 | 125 | 11.5 |
| 1920 | 592 | 16 | 2.7 | 218 | 96 | 44.0 | 55 | 44 | 80.0 | 865 | 156 | 18.0 |
| 1930 | 446 | 47 | 10.5 | 231 | 132 | 57.1 | 63 | 52 | 82.5 | 740 | 231 | 31.2 |
| EAST SOUTH CENTRAL | | | | | | | | | | | | |
| Kentucky | | | | | | | | | | | | |
| 1900 | 2781 | 115 | 4.1 | 268 | 149 | 55.6 | 50 | 45 | 90.0 | 3099 | 309 | 10.0 |
| 1910 | 3270 | 124 | 3.8 | 292 | 172 | 58.9 | 65 | 59 | 90.8 | 3627 | 355 | 9.8 |
| 1920 | 2996 | 78 | 2.6 | 323 | 162 | 50.2 | 70 | 59 | 84.3 | 3389 | 299 | 8.8 |
| 1930 | 2632 | 85 | 3.2 | 342 | 157 | 45.9 | 103 | 74 | 71.8 | 3077 | 316 | 10.3 |
| Tennessee | | | | | | | | | | | | |
| 1900 | 2720 | 6 | .2 | 195 | 35 | 17.9 | 58 | 31 | 53.4 | 2973 | 72 | 2.4 |
| 1910 | 2237 | 27 | 1.2 | 228 | 83 | 36.4 | 65 | 50 | 76.9 | 2530 | 160 | 6.3 |
| 1920 | 1208 | 25 | 2.1 | 245 | 97 | 39.6 | 51 | 41 | 80.4 | 1504 | 163 | 10.8 |
| 1930 | 946 | 36 | 3.8 | 234 | 100 | 42.7 | 61 | 49 | 80.3 | 1241 | 185 | 14.9 |
| Alabama | | | | | | | | | | | | |
| 1900 | 2091 | 34 | 1.6 | 245 | 98 | 40.0 | 45 | 33 | 73.3 | 2381 | 165 | 6.9 |
| 1910 | 1647 | 37 | 2.2 | 330 | 141 | 42.7 | 73 | 55 | 75.3 | 2050 | 233 | 11.4 |
| 1920 | 1015 | 34 | 3.3 | 309 | 136 | 44.0 | 85 | 61 | 71.8 | 1409 | 231 | 16.4 |
| 1930 | 729 | 46 | 6.3 | 293 | 133 | 45.4 | 102 | 64 | 62.7 | 1124 | 243 | 21.6 |
| Mississippi | | | | | | | | | | | | |
| 1900 | 1700 | 82 | 4.8 | 142 | 94 | 66.2 | 32 | 28 | 87.5 | 1874 | 204 | 10.9 |
| 1910 | 1895 | 118 | 6.2 | 218 | 147 | 67.4 | 48 | 46 | 95.8 | 2161 | 311 | 14.4 |
| 1920 | 1234 | 72 | 5.8 | 219 | 144 | 65.8 | 56 | 53 | 94.6 | 1509 | 269 | 17.8 |
| 1930 | 784 | 69 | 8.8 | 221 | 150 | 67.9 | 61 | 55 | 90.2 | 1066 | 274 | 25.7 |
| WEST SOUTH CENTRAL | | | | | | | | | | | | |
| Arkansas | | | | | | | | | | | | |
| 1900 | 1640 | 32 | 2.0 | 215 | 98 | 45.6 | 41 | 37 | 90.2 | 1896 | 167 | 8.8 |
| 1910 | 1798 | 81 | 4.5 | 264 | 142 | 53.8 | 57 | 54 | 94.7 | 2119 | 277 | 13.1 |
| 1920 | 1397 | 69 | 4.9 | 297 | 175 | 58.9 | 62 | 57 | 91.9 | 1756 | 301 | 17.1 |
| 1930 | 1080 | 98 | 9.1 | 287 | 185 | 64.5 | 62 | 57 | 91.9 | 1429 | 340 | 23.8 |
| Louisiana | | | | | | | | | | | | |
| 1900 | 968 | 10 | 1.0 | 167 | 55 | 32.9 | 30 | 23 | 76.7 | 1165 | 88 | 7.6 |
| 1910 | 1107 | 11 | 1.0 | 259 | 97 | 37.5 | 49 | 38 | 77.6 | 1415 | 146 | 10.3 |
| 1920 | 814 | 13 | 1.6 | 267 | 99 | 37.1 | 64 | 44 | 68.8 | 1145 | 156 | 13.6 |
| 1930 | 644 | 10 | 1.6 | 261 | 100 | 38.3 | 76 | 52 | 68.4 | 981 | 162 | 16.5 |
| Oklahoma | | | | | | | | | | | | |
| 1900 | 553 | 27 | 4.9 | 80 | 59 | 73.8 | 26 | 26 | 100.0 | 659 | 112 | 17.0 |
| 1910 | 1275 | 50 | 3.9 | 281 | 225 | 80.1 | 78 | 71 | 91.0 | 1634 | 346 | 21.2 |
| 1920 | 874 | 65 | 7.4 | 316 | 241 | 76.3 | 105 | 96 | 91.4 | 1295 | 402 | 31.0 |
| 1930 | 710 | 102 | 14.4 | 322 | 245 | 76.1 | 105 | 98 | 93.3 | 1137 | 445 | 39.1 |
| Texas | | | | | | | | | | | | |
| 1900 | 2470 | 2 | .08 | 460 | 68 | 14.8 | 129 | 68 | 52.7 | 3059 | 138 | 4.5 |
| 1910 | 2705 | 4 | .1 | 654 | 102 | 15.6 | 202 | 123 | 60.9 | 3561 | 229 | 6.4 |
| 1920 | 2071 | 7 | .3 | 714 | 155 | 21.7 | 229 | 166 | 72.5 | 3014 | 328 | 10.9 |
| 1930 | 1785 | 10 | .6 | 829 | 222 | 26.8 | 255 | 189 | 74.1 | 2869 | 421 | 14.7 |
| MOUNTAIN | | | | | | | | | | | | |
| Montana | | | | | | | | | | | | |
| 1900 | 429 | 1 | .2 | 52 | 7 | 13.5 | 13 | 8 | 61.5 | 494 | 16 | 3.2 |
| 1910 | 647 | — | — | 72 | 31 | 43.1 | 19 | 12 | 63.2 | 738 | 43 | 5.8 |
| 1920 | 564 | 3 | .5 | 121 | 60 | 49.6 | 26 | 24 | 92.3 | 615 | 87 | 12.2 |
| 1930 | 472 | 8 | 1.7 | 117 | 66 | 56.4 | 26 | 24 | 92.3 | 615 | 98 | 15.9 |
| Idaho | | | | | | | | | | | | |
| 1900 | 354 | 2 | .6 | 67 | 21 | 31.3 | 14 | 9 | 64.3 | 435 | 32 | 7.4 |
| 1910 | 480 | 15 | 3.1 | 100 | 55 | 55.0 | 21 | 19 | 90.5 | 601 | 89 | 14.8 |
| 1920 | 334 | 17 | 5.1 | 120 | 81 | 67.5 | 25 | 22 | 88.0 | 479 | 120 | 25.1 |
| 1930 | 285 | 30 | 10.5 | 149 | 77 | 51.7 | 23 | 22 | 95.7 | 457 | 129 | 28.2 |

Table 11 Continued.

| State and year | Hamlets Total number | Hamlets incorporated Number | Hamlets incorporated Per cent | Small villages Total number | Small villages incorporated Number | Small villages incorporated Per cent | Large villages Total number | Large villages incorporated Number | Large villages incorporated Per cent | Total places Total number | Total places incorporated Number | Total places incorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wyoming** | | | | | | | | | | | | |
| 1900 | 258 | 2 | .8 | 18 | 8 | 44.4 | 6 | 4 | 66.7 | 282 | 14 | 5.0 |
| 1910 | 318 | 13 | 4.1 | 42 | 22 | 52.4 | 11 | 6 | 54.5 | 371 | 41 | 11.1 |
| 1920 | 191 | 20 | 10.5 | 37 | 25 | 67.6 | 24 | 19 | 79.2 | 252 | 64 | 25.4 |
| 1930 | 207 | 28 | 13.5 | 47 | 31 | 66.0 | 22 | 17 | 77.3 | 276 | 76 | 27.5 |
| Colorado | | | | | | | | | | | | |
| 1900 | 657 | 41 | 6.4 | 89 | 66 | 74.2 | 22 | 20 | 90.9 | 748 | 127 | 17.0 |
| 1910 | 656 | 59 | 9.0 | 151 | 91 | 60.3 | 27 | 24 | 88.9 | 834 | 174 | 20.9 |
| 1920 | 568 | 60 | 10.6 | 144 | 96 | 66.7 | 42 | 39 | 92.9 | 754 | 195 | 25.9 |
| 1930 | 545 | 68 | 12.5 | 153 | 104 | 68.0 | 47 | 42 | 89.4 | 743 | 214 | 28.8 |
| **New Mexico** | | | | | | | | | | | | |
| 1900 | 254 | — | — | 72 | 2 | 2.8 | 17 | 2 | 11.8 | 343 | 4 | 1.2 |
| 1910 | 438 | 1 | .2 | 133 | 13 | 9.8 | 22 | 6 | 27.3 | 593 | 20 | 3.4 |
| 1920 | 372 | 1 | .3 | 116 | 20 | 17.2 | 27 | 13 | 48.1 | 515 | 34 | 6.6 |
| 1930 | 342 | 4 | 1.2 | 119 | 25 | 21.0 | 25 | 11 | 44.0 | 486 | 40 | 8.2 |
| **Arizona** | | | | | | | | | | | | |
| 1900 | 187 | — | — | 23 | 6 | 26.1 | 8 | 3 | 37.5 | 218 | 9 | 4.1 |
| 1910 | 223 | — | — | 47 | 6 | 12.8 | 12 | 7 | 58.3 | 282 | 13 | 4.6 |
| 1920 | 184 | — | — | 46 | 9 | 19.6 | 17 | 6 | 35.3 | 247 | 15 | 6.1 |
| 1930 | 164 | — | — | 67 | 11 | 16.4 | 21 | 9 | 42.9 | 252 | 20 | 7.9 |
| Utah | | | | | | | | | | | | |
| 1900 | 190 | 1 | .5 | 131 | 31 | 23.7 | 34 | 25 | 73.5 | 355 | 57 | 16.1 |
| 1910 | 173 | 2 | 1.2 | 148 | 53 | 35.8 | 44 | 32 | 72.7 | 365 | 87 | 23.8 |
| 1920 | 165 | 4 | 2.4 | 107 | 64 | 59.8 | 51 | 41 | 80.4 | 323 | 109 | 33.7 |
| 1930 | 130 | 9 | 6.9 | 154 | 79 | 51.3 | 42 | 34 | 81.0 | 326 | 122 | 37.4 |
| **Nevada** | | | | | | | | | | | | |
| 1900 | 169 | — | — | 18 | 1 | 5.6 | 6 | 1 | 16.7 | 193 | 2 | 1.0 |
| 1910 | 204 | — | — | 31 | 4 | 12.9 | 15 | 2 | 13.3 | 250 | 6 | 2.4 |
| 1920 | 91 | 1 | 1.1 | 38 | 3 | 7.9 | 15 | 7 | 46.7 | 144 | 11 | 7.6 |
| 1930 | 91 | 3 | 3.3 | 40 | 3 | 7.5 | 16 | 5 | 31.3 | 147 | 11 | 7.5 |
| PACIFIC | | | | | | | | | | | | |
| Washington | | | | | | | | | | | | |
| 1900 | 689 | 4 | .6 | 106 | 51 | 48.1 | 19 | 18 | 94.7 | 814 | 73 | 9.0 |
| 1910 | 893 | 9 | 1.0 | 170 | 99 | 58.2 | 45 | 42 | 93.3 | 1108 | 150 | 13.5 |
| 1920 | 727 | 18 | 2.5 | 235 | 110 | 46.8 | 51 | 47 | 92.2 | 1013 | 175 | 17.3 |
| 1930 | 653 | 26 | 4.0 | 255 | 115 | 45.1 | 48 | 42 | 87.5 | 956 | 183 | 19.1 |
| Oregon | | | | | | | | | | | | |
| 1900 | 769 | 33 | 4.3 | 77 | 60 | 77.9 | 12 | 9 | 75.0 | 858 | 102 | 11.9 |
| 1910 | 736 | 45 | 6.1 | 100 | 80 | 80.0 | 31 | 28 | 90.3 | 867 | 153 | 17.6 |
| 1920 | 597 | 60 | 10.1 | 104 | 82 | 78.8 | 31 | 30 | 96.8 | 732 | 172 | 23.5 |
| 1930 | 595 | 62 | 10.4 | 107 | 85 | 79.4 | 33 | 29 | 87.9 | 735 | 176 | 23.9 |
| California | | | | | | | | | | | | |
| 1900 | 1416 | 1 | .07 | 276 | 29 | 10.5 | 75 | 42 | 56.0 | 1767 | 72 | 4.1 |
| 1910 | 1482 | 3 | .2 | 301 | 59 | 19.6 | 97 | 66 | 68.0 | 1880 | 128 | 6.8 |
| 1920 | 1000 | 3 | .3 | 384 | 63 | 16.4 | 123 | 74 | 60.2 | 1507 | 140 | 9.3 |
| 1930 | 917 | 6 | .7 | 360 | 42 | 11.7 | 133 | 77 | 57.9 | 1410 | 125 | 8.9 |

[1] Uncorrected Bradstreet data are used for New Hampshire, Massachusetts, and Rhode Island. No small places are incorporated in these states and, therefore, no Census data are available. Correction of Bradstreet estimates for unincorporated places by the method employed is impossible.

Middle Atlantic states: About 95 per cent of the hamlet population has lived in unincorporated territory during the entire period 1900-1930, about 70 per cent of the population in the intermediate classification, and 45 to 50 per cent of the population in the largest classification. There have been no significant changes in the distribution of population in any group of places or in the total number of places during the century.

East North Central states: The striking fact concerning the distribution of population in these states during the years since 1900 is that there has been a consistent decrease in the number of places with under 2500 people and in the percentage of population in each type of place, with the exception of the percentage of population in large villages in 1920. The decrease in the proportion of people in incorporated places reflects either a tendency for places in this section to become incorporated in increasing numbers or for unincorporated places to disappear.

West North Central states: The trend here is practically identical with that in the East North Central section; that is, there is a decreasing proportion of the population living in places of fewer than 2500 people in unincorporated territory; or to state it conversely, an increasing proportion of the population of such places is living in legally incorporated places. The actual number of people living in the village groups has increased, but the number living in unincorporated places has been decreasing since 1910.

South Atlantic States: The most marked change in this division is the decline in proportion of large village population living in unincorporated places. The number of people in unincorporated places has increased in large and small villages but the number in hamlets has declined.

East South Central states: The proportion of the population living in unincorporated places of fewer than 2500 people has fallen from 57.3 per cent in 1900 to 47.2 per cent in 1930, although the actual number living in unincorporated places has increased. The most marked changes in population distribution have been in the large villages. Fluctuations for that group are so violent that apparently a number of large villages either passed the 2500 line and became urban or fell below the line during certain decades, thus changing radically the proportion of people in unincorporated places. The general shift must have been upward,

Table 12. Distribution of Population by Hamlets and Villages and by Number and Percentages in Unincorporated[a] Territory according to Geographical Divisions and to States, 1930[b].

| Division and state | Hamlets: Total number | Hamlets: Unincorporated Number | Hamlets: Unincorporated Per cent | Small villages: Total number | Small villages: Unincorporated Number | Small villages: Unincorporated Per cent | Large villages: Total number | Large villages: Unincorporated Number | Large villages: Unincorporated Per cent | All places: Total number | All places: Unincorporated Number | All places: Unincorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNITED STATES | 2,515,760 | 2,029,819 | 80.7 | 7,191,402 | 3,311,229 | 46.0 | 7,119,703 | 2,301,129 | 32.3 | 16,826,935 | 7,642,177 | 45.4 |
| NEW ENGLAND: | 136,058 | 133,439 | 98.1 | 692,839 | 668,002 | 96.4 | 760,614 | 699,879 | 92.0 | 1,589,491 | 1,501,320 | 94.5 |
| Maine | 57,503 | 57,084 | 99.3 | 201,498 | 193,925 | 96.2 | 160,028 | 144,690 | 90.4 | 419,029 | 395,699 | 94.4 |
| New Hampshire | 23,110 | 23,110 | 100.0 | 87,238 | 87,238 | 100.0 | 70,880 | 70,880 | 100.0 | 181,228 | 181,228 | 100.0 |
| Vermont | 20,732 | 18,558 | 89.5 | 102,990 | 88,221 | 85.7 | 55,542 | 23,109 | 41.6 | 179,264 | 129,888 | 72.5 |
| Massachusetts | 19,021 | 19,021 | 100.0 | 130,067 | 130,067 | 100.0 | 252,675 | 252,675 | 100.0 | 401,763 | 401,763 | 100.0 |
| Rhode Island | 2,365 | 2,365 | 100.0 | 24,078 | 24,078 | 100.0 | 47,185 | 47,185 | 100.0 | 73,628 | 73,628 | 100.0 |
| Connecticut | 13,307 | 13,301 | 99.9 | 146,968 | 144,473 | 98.3 | 174,304 | 161,340 | 92.6 | 334,579 | 319,114 | 95.4 |
| MIDDLE ATLANTIC: | 402,773 | 380,220 | 94.4 | 1,189,547 | 829,203 | 69.7 | 1,367,239 | 639,681 | 46.8 | 2,959,559 | 1,849,104 | 62.5 |
| New York | 189,202 | 185,275 | 97.9 | 433,193 | 301,981 | 69.7 | 403,211 | 174,420 | 43.3 | 1,025,606 | 661,676 | 64.5 |
| New Jersey | 30,003 | 28,012 | 93.4 | 163,086 | 121,497 | 74.5 | 269,424 | 125,106 | 46.4 | 462,513 | 274,615 | 59.4 |
| Pennsylvania | 183,568 | 166,933 | 90.9 | 593,268 | 405,725 | 68.4 | 694,604 | 340,155 | 49.0 | 1,471,440 | 912,813 | 62.0 |
| EAST NORTH CENTRAL: | 406,738 | 330,317 | 81.2 | 1,336,508 | 417,083 | 31.2 | 1,179,423 | 146,200 | 12.4 | 2,922,669 | 893,600 | 30.6 |
| Ohio | 132,910 | 108,551 | 81.7 | 330,766 | 118,339 | 35.8 | 289,042 | 40,379 | 14.0 | 752,718 | 267,269 | 35.5 |
| Indiana | 83,677 | 73,756 | 88.1 | 230,321 | 85,393 | 37.1 | 172,976 | 24,757 | 14.3 | 486,974 | 183,916 | 37.8 |
| Illinois | 81,597 | 54,688 | 67.0 | 341,113 | 44,499 | 13.0 | 334,945 | 7,200 | 2.1 | 757,655 | 106,387 | 14.0 |
| Michigan | 51,628 | 46,522 | 90.1 | 223,648 | 105,815 | 47.3 | 222,897 | 51,517 | 23.1 | 498,173 | 203,854 | 40.9 |
| Wisconsin | 56,926 | 46,800 | 82.2 | 211,513 | 63,037 | 29.8 | 158,710 | 22,337 | 14.1 | 427,149 | 132,174 | 30.9 |
| WEST NORTH CENTRAL: | 407,655 | 214,232 | 52.6 | 1,116,747 | 98,028 | 8.8 | 875,542 | 43,333 | 4.9 | 2,399,944 | 355,593 | 14.8 |
| Minnesota | 70,785 | 33,650 | 47.5 | 179,381 | 11,308 | 6.3 | 140,698 | 5,559 | 4.0 | 390,864 | 50,517 | 12.9 |
| Iowa | 77,164 | 37,022 | 48.0 | 258,908 | 20,537 | 7.9 | 194,410 | 8,001 | 4.1 | 530,482 | 65,560 | 12.4 |
| Missouri | 96,737 | 60,711 | 62.8 | 204,830 | 37,555 | 18.3 | 201,297 | 22,612 | 11.2 | 502,864 | 120,878 | 24.0 |
| North Dakota | 40,359 | 21,892 | 54.2 | 86,535 | 6,293 | 7.3 | 39,232 | | | 166,126 | 28,185 | 17.0 |
| South Dakota | 26,767 | 13,028 | 48.7 | 76,983 | 2,744 | 3.6 | 56,947 | | | 160,697 | 15,772 | 9.8 |
| Nebraska | 36,759 | 12,029 | 32.7 | 140,123 | 2,192 | 1.6 | 109,812 | 2,640 | 2.4 | 286,694 | 16,861 | 5.9 |
| Kansas | 59,084 | 35,900 | 60.8 | 169,987 | 17,399 | 10.2 | 133,146 | 4,521 | 3.4 | 362,217 | 57,820 | 16.0 |
| SOUTH ATLANTIC: | 453,481 | 374,123 | 82.5 | 894,663 | 378,139 | 42.3 | 916,738 | 240,718 | 26.3 | 2,264,882 | 992,980 | 43.8 |
| Delaware | 6,036 | 3,818 | 63.3 | 17,796 | 5,126 | 28.8 | 18,756 | 1,850 | 9.9 | 42,588 | 10,794 | 25.3 |
| Maryland | 34,387 | 30,225 | 87.9 | 87,485 | 49,597 | 56.7 | 68,509 | 31,712 | 46.3 | 190,381 | 111,534 | 58.6 |
| Virginia | 85,636 | 81,851 | 95.6 | 122,933 | 69,065 | 56.2 | 109,509 | 40,410 | 36.9 | 318,078 | 191,326 | 60.2 |
| West Virginia | 106,355 | 103,666 | 97.5 | 161,737 | 110,843 | 68.5 | 167,112 | 68,503 | 41.0 | 435,204 | 283,012 | 65.0 |
| North Carolina | 77,923 | 58,157 | 74.6 | 167,759 | 53,179 | 31.7 | 182,079 | 40,507 | 22.2 | 427,761 | 151,843 | 35.5 |
| South Carolina | 30,029 | 18,358 | 61.1 | 70,639 | 20,181 | 28.6 | 118,697 | 30,583 | 25.8 | 219,365 | 69,122 | 31.5 |
| Georgia | 69,231 | 41,292 | 59.6 | 155,352 | 27,450 | 17.7 | 156,603 | 12,700 | 8.1 | 381,186 | 81,442 | 21.4 |
| Florida | 43,884 | 36,756 | 83.8 | 110,962 | 42,698 | 38.5 | 95,473 | 14,453 | 15.1 | 250,319 | 93,907 | 37.5 |
| EAST SOUTH CENTRAL | 284,616 | 244,788 | 86.0 | 523,237 | 225,204 | 43.0 | 544,335 | 167,725 | 30.8 | 1,352,218 | 637,717 | 47.2 |
| Kentucky | 131,537 | 117,815 | 89.6 | 159,541 | 75,766 | 47.5 | 161,314 | 43,658 | 27.1 | 452,392 | 237,239 | 52.4 |
| Tennessee | 54,994 | 48,580 | 88.3 | 109,953 | 52,539 | 47.8 | 97,149 | 25,141 | 25.9 | 262,096 | 126,260 | 48.2 |
| Alabama | 48,582 | 40,806 | 84.0 | 140,827 | 67,394 | 47.9 | 186,754 | 87,486 | 46.8 | 376,163 | 195,686 | 52.0 |
| Mississippi | 49,533 | 37,587 | 75.9 | 112,916 | 29,505 | 26.1 | 99,118 | 11,440 | 11.5 | 261,567 | 78,532 | 30.0 |
| WEST SOUTH CENTRAL: | 194,661 | 159,221 | 81.8 | 725,396 | 320,420 | 44.2 | 807,354 | 179,084 | 22.2 | 1,727,411 | 658,725 | 38.1 |
| Arkansas | 59,099 | 43,924 | 74.3 | 123,329 | 31,113 | 25.2 | 96,042 | 7,343 | 7.6 | 278,470 | 82,380 | 29.6 |
| Louisana | 24,567 | 22,809 | 92.8 | 121,914 | 67,645 | 55.5 | 121,139 | 43,112 | 35.6 | 267,620 | 133,566 | 49.9 |
| Oklahoma | 39,119 | 22,472 | 57.4 | 145,242 | 23,336 | 16.1 | 168,469 | 8,590 | 5.1 | 352,830 | 54,398 | 15.4 |
| Texas | 71,876 | 70,016 | 97.4 | 334,911 | 198,326 | 59.2 | 421,704 | 120,039 | 28.5 | 828,491 | 388,381 | 46.9 |
| MOUNTAIN: | 112,289 | 89,942 | 80.1 | 371,446 | 166,700 | 44.9 | 342,401 | 90,830 | 26.5 | 826,136 | 347,472 | 42.1 |
| Montana | 12,504 | 10,887 | 87.1 | 50,372 | 17,880 | 35.5 | 38,968 | 2,698 | 6.9 | 101,844 | 31,465 | 30.9 |
| Idaho | 13,832 | 9,302 | 67.2 | 62,005 | 24,758 | 39.9 | 35,081 | 1,560 | 4.4 | 110,918 | 35,620 | 32.1 |
| Wyoming | 9,803 | 5,975 | 61.0 | 24,041 | 9,118 | 37.9 | 41,254 | 13,338 | 32.3 | 75,098 | 28,431 | 37.9 |
| Colorado | 28,649 | 19,279 | 67.3 | 69,509 | 18,040 | 26.0 | 68,891 | 8,065 | 11.7 | 167,049 | 45,384 | 27.2 |
| New Mexico | 15,617 | 14,804 | 94.8 | 57,412 | 42,890 | 74.7 | 35,171 | 17,713 | 50.4 | 108,200 | 75,407 | 69.7 |
| Arizona | 9,602 | 9,602 | 100.0 | 22,277 | 13,108 | 58.8 | 35,194 | 20,283 | 57.6 | 67,073 | 42,993 | 64.1 |
| Utah | 15,970 | 14,236 | 89.1 | 68,216 | 25,071 | 36.7 | 64,519 | 11,461 | 17.8 | 148,735 | 50,768 | 34.1 |
| Nevada | 6,312 | 5,857 | 92.8 | 17,584 | 15,835 | 90.1 | 23,323 | 15,712 | 67.4 | 47,219 | 37,404 | 79.2 |
| PACIFIC: | 117,479 | 103,537 | 88.1 | 340,236 | 208,450 | 61.3 | 326,910 | 93,679 | 28.7 | 784,625 | 405,666 | 51.7 |
| Washington | 28,122 | 23,668 | 84.2 | 108,978 | 49,120 | 45.1 | 70,801 | 7,788 | 11.0 | 207,901 | 80,576 | 38.8 |
| Oregon | 21,415 | 12,744 | 59.5 | 57,864 | 15,539 | 26.9 | 51,282 | 4,928 | 9.6 | 130,561 | 33,211 | 25.4 |
| California | 67,942 | 67,125 | 98.8 | 173,394 | 143,791 | 82.9 | 204,827 | 80,963 | 39.5 | 446,163 | 291,879 | 65.4 |

[a] Uncorrected Bradstreet data are used for New Hampshire, Massachusetts, and Rhode Island. No small places are incorporated in these states and, therefore, no Census data are available. Correction of Bradstreet estimates for unincorporated places by the method employed is impossible.

[b] Because of the method of handling towns located on state boundaries, these figures differ from Census figures by a few hundred in certain states: namely, Ohio and Indiana, Deleware and Maryland, Arkansas and Louisiana, Oklahoma and Texas, and in their respective geographic regions. National figures given here exceed the Census total by 1305, as this number of people of an Indiana city are located in Ohio and so included in our total.

Table 13. Distribution of Population by Hamlets and Villages and by Number and Percentages in Unincorporated Territory according to Geographical Divisions and Decades, 1900-30[a].

| Division and year | Hamlets: Total number | Hamlets: Unincorporated Number | Hamlets: Unincorporated Per cent | Small villages: Total number | Small villages: Unincorporated Number | Small villages: Unincorporated Per cent | Large villages: Total number | Large villages: Unincorporated Number | Large villages: Unincorporated Per cent | All places: Total number | All places: Unincorporated Number | All places: Unincorporated Per cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NEW ENGLAND: | | | | | | | | | | | | |
| 1900 | 121,862 | 121,106 | 99.4 | 515,698 | 499,894 | 96.9 | 818,222 | 749,854 | 91.6 | 1,455,722 | 1,370,854 | 94.2 |
| 1910 | 184,266 | 183,096 | 99.4 | 696,963 | 677,546 | 97.2 | 941,781 | 887,555 | 94.2 | 1,823,010 | 1,748,197 | 95.9 |
| 1920 | 151,798 | 149,669 | 98.6 | 652,723 | 632,148 | 96.8 | 680,341 | 628,290 | 92.3 | 1,484,862 | 1,410,107 | 95.0 |
| 1930 | 136,038 | 133,439 | 98.1 | 692,839 | 668,002 | 96.4 | 760,614 | 699,879 | 92.0 | 1,589,491 | 1,501,320 | 94.5 |
| MIDDLE ATLANTIC: | | | | | | | | | | | | |
| 1900 | 518,562 | 498,487 | 96.1 | 1,106,132 | 767,197 | 69.4 | 1,229,841 | 620,680 | 50.5 | 2,854,535 | 1,886,364 | 66.1 |
| 1910 | 490,804 | 470,958 | 96.0 | 1,178,007 | 825,564 | 70.1 | 1,315,325 | 603,056 | 45.8 | 2,984,136 | 1,899,578 | 63.7 |
| 1920 | 403,436 | 379,619 | 94.1 | 1,127,807 | 795,552 | 70.5 | 1,328,376 | 624,628 | 47.0 | 2,859,619 | 1,799,799 | 62.9 |
| 1930 | 402,773 | 380,220 | 94.4 | 1,189,547 | 829,203 | 69.7 | 1,367,239 | 639,681 | 46.8 | 2,959,559 | 1,849,104 | 62.5 |
| EAST NORTH CENTRAL: | | | | | | | | | | | | |
| 1900 | 526,951 | 488,101 | 92.6 | 1,243,944 | 477,479 | 38.4 | 1,106,755 | 209,639 | 18.9 | 2,877,650 | 1,175,219 | 40.8 |
| 1910 | 473,828 | 418,739 | 88.4 | 1,343,575 | 444,911 | 33.1 | 1,147,943 | 148,906 | 13.0 | 2,965,346 | 1,012,556 | 34.1 |
| 1920 | 446,275 | 378,145 | 84.7 | 1,330,497 | 428,900 | 32.2 | 1,167,034 | 156,349 | 13.4 | 2,943,806 | 963,394 | 32.7 |
| 1930 | 406,738 | 330,317 | 81.2 | 1,337,361 | 417,083 | 31.2 | 1,178,570 | 146,200 | 12.4 | 2,922,669 | 893,600 | 30.6 |
| WEST NORTH CENTRAL: | | | | | | | | | | | | |
| 1900 | 352,138 | 262,397 | 74.5 | 892,391 | 172,039 | 19.3 | 736,275 | 65,423 | 8.9 | 1,980,804 | 499,859 | 25.2 |
| 1910 | 395,437 | 249,679 | 63.1 | 1,073,096 | 140,157 | 13.1 | 826,526 | 43,978 | 5.3 | 2,295,059 | 433,814 | 18.9 |
| 1920 | 416,208 | 255,216 | 61.3 | 1,167,285 | 137,591 | 11.8 | 907,556 | 40,343 | 4.4 | 2,491,049 | 433,150 | 17.4 |
| 1930 | 407,655 | 214,232 | 52.6 | 1,116,747 | 98,028 | 8.8 | 875,542 | 43,333 | 4.9 | 2,399,944 | 355,593 | 14.8 |
| SOUTH ATLANTIC: | | | | | | | | | | | | |
| 1900 | 480,511 | 422,667 | 88.0 | 574,088 | 236,644 | 41.2 | 504,712 | 185,936 | 36.8 | 1,559,311 | 845,247 | 54.2 |
| 1910 | 637,765 | 554,037 | 86.9 | 813,431 | 358,010 | 44.0 | 749,928 | 224,641 | 30.0 | 2,201,124 | 1,136,688 | 51.6 |
| 1920 | 500,329 | 432,006 | 86.3 | 858,333 | 381,249 | 44.4 | 837,546 | 239,689 | 28.6 | 2,196,208 | 1,052,944 | 47.9 |
| 1930 | 453,481 | 374,123 | 82.5 | 894,663 | 378,139 | 42.3 | 916,738 | 240,718 | 26.3 | 2,264,882 | 992,980 | 43.8 |
| EAST SOUTH CENTRAL: | | | | | | | | | | | | |
| 1900 | 364,026 | 324,017 | 89.0 | 360,544 | 172,144 | 47.7 | 297,323 | 89,158 | 30.0 | 1,021,893 | 585,319 | 57.3 |
| 1910 | 387,079 | 337,515 | 87.2 | 483,626 | 203,266 | 42.0 | 408,001 | 80,235 | 19.7 | 1,278,706 | 621,014 | 48.6 |
| 1920 | 287,695 | 251,447 | 87.4 | 511,211 | 220,922 | 43.2 | 413,947 | 82,666 | 20.0 | 1,212,853 | 555,035 | 45.8 |
| 1930 | 284,646 | 244,788 | 86.0 | 523,237 | 225,204 | 43.0 | 544,335 | 167,725 | 30.8 | 1,352,218 | 637,717 | 47.2 |
| WEST SOUTH CENTRAL: | | | | | | | | | | | | |
| 1900 | 315,459 | 302,255 | 95.8 | 391,814 | 238,200 | 60.8 | 320,396 | 73,848 | 23.0 | 1,027,669 | 614,303 | 59.8 |
| 1910 | 310,686 | 285,999 | 92.1 | 638,543 | 336,065 | 52.6 | 656,870 | 212,576 | 32.4 | 1,606,099 | 834,641 | 52.0 |
| 1920 | 259,029 | 232,073 | 89.6 | 717,332 | 350,755 | 48.9 | 743,171 | 168,692 | 22.7 | 1,719,532 | 751,520 | 43.7 |
| 1930 | 194,661 | 159,221 | 81.8 | 725,396 | 320,420 | 44.2 | 807,354 | 179,084 | 22.2 | 1,727,411 | 658,725 | 38.1 |
| MOUNTAIN: | | | | | | | | | | | | |
| 1900 | 108,843 | 102,305 | 94.0 | 213,850 | 133,516 | 62.4 | 213,482 | 100,908 | 47.3 | 536,175 | 336,729 | 62.8 |
| 1910 | 143,553 | 130,363 | 90.8 | 319,255 | 169,658 | 53.1 | 286,293 | 114,059 | 39.8 | 749,101 | 414,080 | 55.3 |
| 1920 | 111,761 | 95,942 | 85.8 | 327,765 | 142,670 | 43.5 | 356,374 | 93,193 | 26.2 | 795,900 | 331,805 | 41.7 |
| 1930 | 112,289 | 89,942 | 80.1 | 371,446 | 166,700 | 44.9 | 342,401 | 90,830 | 26.5 | 826,136 | 347,472 | 42.1 |
| PACIFIC: | | | | | | | | | | | | |
| 1900 | 139,603 | 132,844 | 95.2 | 184,052 | 105,232 | 57.2 | 155,827 | 47,054 | 30.2 | 479,482 | 285,130 | 59.5 |
| 1910 | 123,469 | 114,417 | 92.7 | 305,998 | 170,641 | 55.8 | 289,708 | 70,791 | 24.4 | 719,175 | 355,849 | 49.5 |
| 1920 | 111,778 | 99,030 | 88.6 | 302,211 | 160,375 | 53.1 | 300,156 | 84,634 | 28.2 | 714,145 | 344,039 | 48.2 |
| 1930 | 117,479 | 103,537 | 88.1 | 340,236 | 208,450 | 61.3 | 326,910 | 93,679 | 28.7 | 784,625 | 405,666 | 51.7 |

[a] Uncorrected Bradstreet data are used for New Hampshire, Massachusetts, and Rhode Island. No small places are incorporated in these states and, therefore, no Census data are available. Correction of Bradstreet estimates for unincorporated places by the method employed is impossible.

inasmuch as no great fluctuations are noticeable in the number or percentage of people in unincorporated places in the two smaller groups of places. It is possible, of course, that peculiarities of reporting by Bradstreet agents may be responsible.

West South Central states: There has been a considerable decline in the number and proportion of people in unincorporated places in the two smaller classifications and in the total number of places during the last decade and, in fact, during most decades of the century. The proportion of large incorporated villages reached a peak in 1910 but thereafter dropped to the level of 1900.

Mountain states: Decline in the proportion of population in incorporated places was characteristic for the period of study except for the two largest classes of places during the last decade, and for the total number of places during the last decade.

Pacific states: Trends are practically identical with those of the Mountain division. The most interesting point in the Pacific group is the marked rise during the last decade in population in places of fewer than 250 people.

For the purposes of many research workers the approximate number of people living in incorporated and unincorporated places in their respective states or divisions will be much more useful than the comments made concerning the table. The figures, therefore, need no further interpretation.

## SUMMARY OF FINDINGS

1. In 1930 there were, according to estimates in this study, almost seventeen million (16,826,935) people in the nation living in places of under 2500 people, or, in other words, about 14 per cent of the total population was living in such places. Of these people almost half (7,642,177, or 45.4 per cent) were living in unincorporated places and therefore are not reported as hamlet and village residents by the Census. The group may be even larger since data on which the findings are based are from commercial rating volumes which list only places with mercantile enterprises. The remaining places are incorporated and therefore reported separately by the Census.

2. There were 56,575 places with fewer than 2500 people in the United States in 1930, the number having decreased from a high point of 75,436 in 1910. The decrease is accounted for by the decline of hamlets, a third of which have disappeared since 1900. The extent to which this fluctuation represents historical fact is impossible to tell. Without doubt it is in part due to the source of data. Certainly many hamlets disappeared as commercial centers, but perhaps not in all cases or even in most cases as population aggregates. The two village groups have increased very little in numbers in recent decades; in fact, each decade shows a falling rate of increase. During the same time urban populations (places of 2500 people and above) have shown a much greater rate of increase.

3. In 1930 about 600,000 fewer people lived in hamlets listed by Bradstreet than in 1910. More people lived in the two larger classes of places in 1930 than at any previous period. The rate of increase in the number of people living in places of less than 2500 population has been much smaller than the rate of increase in the total population of the United States.

4. The proportion of people in the places with under 2500 population living in hamlets fell from 21.2 per cent in 1900 to 14.9 per cent in 1930. The percentage living in the two larger classifications were approximately equal during all decades, each containing about 42 per cent of the population in the under-2500-population group in 1930.

5. In 1900, 18.2 per cent of the nation's population lived in the places of under 2500 people covered by this study, whereas in 1930 only 13.7 per cent lived in such places. The percentage living in each type of place has fallen, but the most extreme decline has been in the group with under 250 people, which has lost almost half of its proportion of the nation's people—3.9 per cent in 1900 as compared to 2.0 per cent in 1930. Factors discussed under point "2" above must be taken into account in interpreting this decline. The Census shows that during the period 1900-30 the total rural population fell from 60 per cent of the nation's total to 43.8 per cent of the nation's total.

6. The percentage of the total *rural* population (all population in places of under 2500 people and in the open country) of the nation living in places with fewer than 250 people has been fairly constant during the thirty years covered by the study.

In 1930, 31.3 per cent of the rural population lived in places of fewer than 2500 people.

7. In 1920, 81.9 per cent of the *rural non-farm* population lived in places of fewer than 2500 people; in 1930, 71.1 per cent. Apparently almost 30 per cent of the rural non-farm population lived in the open country in 1930. Over 10 per cent lived in places with under 250 people, and about 60 per cent in the two village classifications. The fact that Bradstreet lists only commercial centers with at least one mercantile unit may mean that certain population aggregates are omitted from these calculations. This would make the situation less extreme than reported here. But granting this possibility, it

would seem that the terms "village population" and "rural non-farm population" should not be used interchangeably.

8. Incorporation of small places is most customary in the West North Central division, least customary in New England. In most sections the percentage of places incorporated was greater in 1930 than during previous decades.

A final word of caution is necessary. The data and conclusions presented in this paper are subject to the limitations of the source material and of the method employed. No one should use the conclusions without studying for himself the procedure employed, a description of which appears in the early part of the paper. The data are but rough estimates in a field where no better information is now, or is likely to be, available for the period of years covered. It is hoped that the federal Census may soon find it possible to enumerate separately populations of unincorporated places. Until such time, the extent of error in the present study remains a matter of conjecture.

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## ERRATA

In Harry F. Clements's "Mechanisms of Freezing Resistance in the Needles of *Pinus ponderosa* and *Pseudotsuga mucronata*," delete the third line on page 38 (beginning "to low temperatures"), and substitute, "succulence of tissue is an attribute to drought resistance, drought" (not followed by a period).

In Newton Jesse Aiken's "A Comparison of an English Classification Test and a Psychological Examination at the College Level," page 122, line 22, change ".19" to ".17."

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